and

SCOPE

# Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P.O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings as 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Tuesday and Sunday, 4 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.


# Sky and TELESCOPE






# In Focus

RESOLVING POWER is the supreme test of the excellence of a telescope objective. This month's back-cover photograph was made by the 200-inch telescope under only moderately good atmospheric conditions, yet it resolves into its individual stars the amorphous elliptical galaxy known as NGC 147, in Cassiopeia. With the corrections recently made to its figure, the 200-inch pyrex eye now performs as well as the best existing large mirrors.

The size of the smallest image shown on the photograph of NGC 147 is 0.57 second of arc, or about 0.0018 inch in diameter on the original negative. As the theoretical size of the spurious disk is only about 1/10 this value, we may expect the 200-inch mirror to concentrate light into a still smaller image when the instrument is used under the best seeing conditions.

On December 12th, in announcing completion of the refiguring of the mirror, Dr. Ira S. Bowen, director of Mount Wilson and Palomar Observatories, stated, "The full gain of the 200-inch over the 100-inch will not be realized until a Ross corrector lens now being made has been completed and installed. The lens will give the Hale instrument the same focal ratio as the 100-inch and we will then be able to get accurate comparable photographs."

The first spectrographic work with the Hale telescope will begin in March, at the prime focus, on a program of measuring the radial velocities of distant galaxies, important to the problem of the expanding universe.

At present many standard objects are being directly photographed: star clusters, nebulae, nearby galaxies, of which NGC 147 is one. About six years ago it was resolved into stars by Dr. Walter Baade, using red-sensitive plates and the 100-inch telescope. NGC 147 is possibly associated with M31, the great Andromeda galaxy, seven degrees away in the sky. Their distances are about the same — 750,000 light-years. (See **Sky and Telescope**, IV, 2, page 10, December, 1944.)


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COVER: The building and dome housing the 24-inch Schmidt-type Heber Doust Curtis memorial telescope of the University of Michigan. The site is near Portage Lake, Mich., about 18 miles northwest of the university campus at Ann Arbor. University of Michigan News Service photograph. (See page 79.)



BACK COVER: A photograph of NGC 147 taken ith the 200-inch Hale telescope. It is clearly resolved into stars (grain in the te shows in the halo around the bright star at the top). The galaxy is of 12. apparent magnitude, measures about 6.5 by 3.8 minutes of arc, and is located in Cassiopeia, at $0^h\ 30^m.4$, $+48°\ 14'$ (1950 co-ordinates). Mount Wilson ar Palomar Observatories photograph. (See In Focus.)


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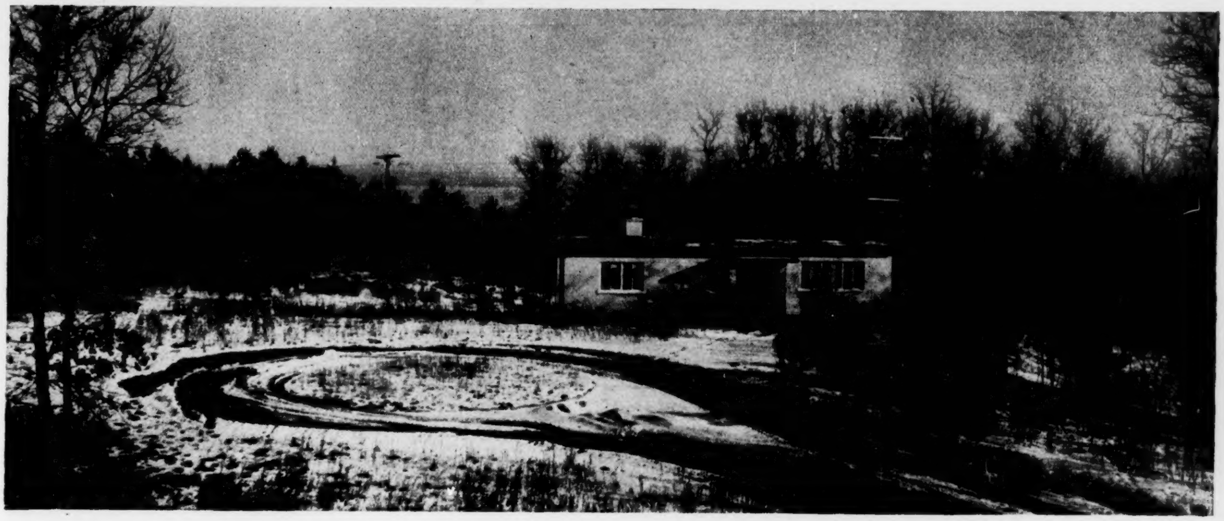


**The driveway and residential building at Portage Lake Observatory. University of Michigan News Service photograph.**

# THE PORTAGE LAKE OBSERVATORY
## OF THE UNIVERSITY OF MICHIGAN

BY FREEMAN D. MILLER, *University of Michigan Observatory*

THE NEW Schmidt telescope of the University of Michigan is a product of the postwar decision of the university administration to broaden its facilities for research and graduate training in astronomy. In the early '30's, plans had been formulated by Dr. Heber D. Curtis, who was then director, for a 97½-inch reflector, but a review of the situation in 1945 indicated that the project was no longer feasible, and it was abandoned.

In 1946 the astronomical equipment of the observatory included the 37½-inch reflector with its spectrographic accessories, the powerful solar equipment of the McMath-Hulbert Observatory, and the 27-inch visual refractor at the Lamont-Hussey Observatory in South Africa. These represent a versatile range of instrumental types, but it will be observed that a modern, wide-field telescope is not included. It was therefore inevitable that the unique capabilities of the Schmidt should receive serious consideration, and it was not long before the principal remaining question was only of the exact design to be adopted.

Modifications of Schmidt's basic plan offer the advantages of flat field and short tube length, but it was considered that overriding benefits would result from the duplication of an existing, very successful instrument. In the hands of Dr. J. J. Nassau and his colleagues at the Warner and Swasey Observatory, the Burrell memorial telescope has performed in such admirable fashion that no hesitation was felt in settling on an identical Schmidt for Michigan.

In December, 1947, a grant of $100,000 from the McGregor fund (already known to astronomers for its generous support of the McMath-Hulbert Observatory) and an appropriation of $160,000 by the university made it possible to ask the Warner and Swasey Company to construct a twin of the Case Institute telescope.

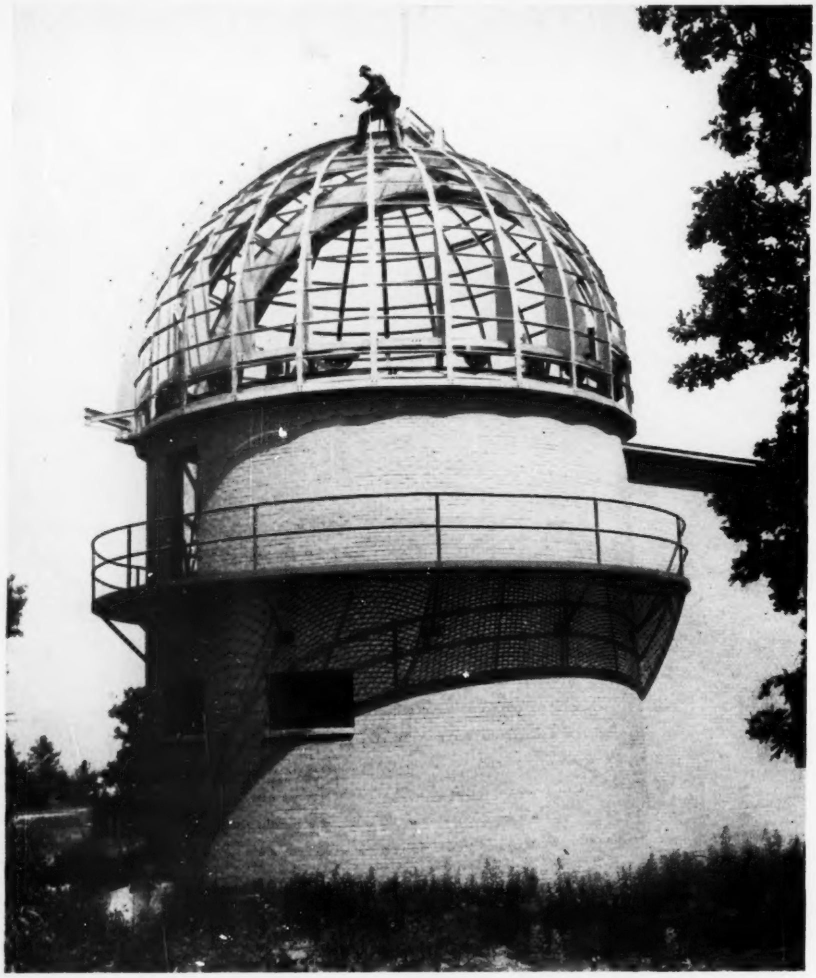

**The scale of this geological survey map is about one mile to an inch (1/62,500). The observatory location is marked near the center, with the road leading to it. The "Prospect Hill" designation does not apply to the observatory's site.**

In all respects the new instrument will resemble its prototype which was pictured on the back cover of *Sky and Telescope* for February, 1942. The clear aperture is 24 inches, diameter of mirror 36 inches, focal length 84 inches, and the focal ratio therefore 3.5.

Two prisms of four and six degrees refracting angle, respectively, have been ordered. Used in combination, they may be counterrotated to provide any effective refracting angle between two and 10 degrees. At the latter setting, the dispersion will be somewhat greater than the minimum provided by the slit spectrographs of the 37½-inch reflector in Ann Arbor. It is anticipated that the alliance between the wide-field Schmidt and the reflector with its numerous spectrograph and camera combinations will prove most fruitful.

With the exception of the prism blanks, the optical problems have been solved with surprising ease. Contracts for the mirror and correcting plate as well as for the two prisms were placed with the Perkin-Elmer Corporation. The normal delay in obtaining a large mirror blank was happily eliminated when Dr. John A. Anderson offered to the Michigan Observatory a pyrex disk owned by the 200-inch telescope project. Work on the mirror could therefore begin promptly, and a disk to replace the "loan" was ordered from the Corning Glass Company.

Finally, a 9-inch objective, figured by Dr. A. K. Pierce of the observatory



**This is the Schmidt building as it appeared during construction, before the dome received its covering. Note the structure of the supporting ribs. University of Michigan News Service photograph.**

staff and his father, was purchased for the guiding telescope. All optical parts except the prisms have thus been completed, and as this article is written, it is anticipated that the first test plates will be taken within a few days.

Guided by the experience of the Warner and Swasey Observatory astronomers, provision has been made for a frequency-control unit to iron out possible fluctuations in the power lines which feed the synchronous drive of the polar axis. The unit was constructed at the McMath-Hulbert Observatory and is similar to the ones already in use there.

The "home" observatory near the university campus in Ann Arbor is now about the last place one would choose to erect a large telescope. City lights, nearby university buildings, and voluminous smoke from a large power plant all conspire against the astronomer. In recent years, only improved photographic emulsions, an aluminized mirror, and coated spectrograph optics have enabled the spectroscopic observers led by Dr. D. B. McLaughlin to continue effective use of the 37½-inch reflector. Although selection of a site outside the city was mandatory, accessibility had also to be considered; graduate students must be able to work with the new instrument and at the same time continue their classes on the campus.

Protracted search for a suitable location was fortunately unnecessary. Fifteen miles northwest of Ann Arbor is a wooded area of some 900 acres controlled by the forestry and conservation department of the university. The chosen site, on a flat-topped ridge a thousand feet above sea level, commands a splendid view of lakes and farming country. Encroachment by domestic and commercial building on the tract is impossible. Detroit is 40 miles away, and downwind under prevailing weather conditions. Only the little village of Dexter, seven miles distant, and numerous summer cottages on the lake shores break the predominantly rural character of the surrounding Michigan countryside.

The adoption of an existing telescope design left the observatory staff free to concentrate on plans for the two buildings which together form the Portage Lake Observatory. The fund of experience acquired by Judge H. S. Hulbert and Dr. R. R. McMath in the development of the solar observatory was invaluable during this period. Astronomical and aesthetic requirements were nicely blended by the architectural firm of Colvin and Heller, with the results shown here and on the front cover.

The ground floor of the telescope building provides unheated garage and storage space. At the observing floor level, 15 feet above ground level, the rectangular section includes a roomy plateholder loading closet and a deep bay which opens without obstruction to the observing floor proper. The bay will accommodate the observer's desk, and has, at its far end, a trap door and sturdy crane. Heavy pieces of equipment such as the mirror (which will be taken to Ann Arbor periodically for re-aluminizing) can be swung through the trap to a truck backed into the garage entrance.

The darkroom itself is underground. The slight inconvenience of this location is more than offset by its relatively cool summer temperature and the elimination of heat radiation from any part of the above-ground structure in winter.

Northeast of the telescope is the residential building, constructed, like the observatory, of sand-colored brick. Here are two bedroom-studies, each with a double-decked bed; a large common room for study, dining, and relaxation; and a completely outfitted kitchen of generous dimensions. The basement houses the oil furnace, well pump, and a workshop, with adequate space left for future needs.

It is especially suitable that this telescope, which will be a powerful tool in the exploration of galactic structure and related problems, should bear the name of Heber D. Curtis, an early champion of the extragalactic character of the spiral nebulae, and director of the Observatory of the University of Michigan from 1930 until his death in 1942. In his honor a dedication program has been planned for June; invited speakers who have already signified their acceptance include Drs. Baade, Lindblad, Mayall, McCuskey, Miller, Minkowski, Morgan, Nassau, Shapley, Stebbins, and Vyssotsky, and Mr. Henize.

The program will open with a public address by Dr. Walter Baade on Thursday evening, June 22nd, and the following day will be occupied by a symposium on "The Structure of the Galaxy." Finally, on the morning of June 24th, at the Portage Lake Observatory, the new Schmidt will be formally dedicated as the Heber Doust Curtis memorial telescope.

# NEWS NOTES

By Dorrit Hoffleit

## *ACTION ON THE SUN*

The latest edition of motion pictures taken at the High Altitude Observatory of Harvard and the University of Colorado was shown by Dr. Donald H. Menzel at the meeting of Section D, American Association for the Advancement of Science, in New York on December 28th. A study of some 15,000 feet of motion picture film taken since 1943, chiefly by Dr. Walter O. Roberts, has led, Dr. Menzel told his audience, to a complete revision of the classification system for solar prominences and has resulted in a new theory of prominences, flares, the corona, and the relation of these phenomena to the earth.

In such records of prominence activity, downward moving matter appears to be much more prevalent than that rising upward. Dr. Menzel proposes that the source of the downward moving matter is the sun's polar spicules. These comparatively small bright jets, recently discovered by Dr. Roberts, are seen close to the sun's surface in its polar regions; each shoots out a core of luminous gas that fades away while it is still rising. "In all probability," Dr. Menzel said, "these expanding jets go to form the solar corona." The curves of the corona follow lines of magnetic force.

"We must regard the complex network of magnetic lines of force around the sun as a sort of semi-flexible roof to the sun. If the concentration of coronal material in some region becomes too great, these lines of force will sag — as if a pocket of snow were causing partial collapse of a tent whose roof was made of rubber . . . . Much the same sort of condition obtains on the sun. The prominences other than those associated with sunspots are largely due to such caving action."

The motion pictures show many examples of matter (hot gases) streaming through a funnel-shaped region whose shape remained relatively constant even though the matter itself was continually changing. Occasionally the internal pressure of the gases moving inside the funnel is so great that the walls break and matter streams forth in graceful curves, carrying the lines of magnetic force along with it.

Long, filamentary regions of prominences stretching as much as a million miles across the solar disk are possibly caused by a series of funnels with stretched zones between. When the magnetic force lines tend to shorten suddenly they may account for rapidly expanding arch-type prominences.

From Dr. Menzel's theory it may follow that any matter reaching the earth from the sun must come from the polar spicules. The observed correlation of flares on the sun with magnetic storms 24 hours later on the earth would then simply mean that both had a common origin, as Dr. Menzel believes that flares do not necessarily eject material outward from the sun.

## *SOLAR HEATING*

At the present rate, the United States consumes annually some 3,500 million dollars worth of fuel for heating. Do we have to continue to rely on fossil-fuel alone? Dr. Maria Telkes, Massachusetts Institute of Technology, discusses the problems of solar heating in the December issue of the *Scientific Monthly*. A solar heat collector used for water heating can be designed to utilize 50 per cent of the incident solar radiation on an average day. The critical problem is the storage of this heat not only overnight but for a sequence of cloudy days. The specific heat of water will permit the storage of probably not more than 20 B.T.U. per pound of water on a winter day. This is too low. Heat of transformation or of fusion of compounds is also to be considered. Several compounds with a heat storing capacity of 100 B.T.U. are available at low cost, such as sodium sulphate decahydrate or disodium phosphate dodecahydrate. These substances can store as much heat as is required to melt them, and when they lose heat they recrystallize. Thus the same material can be reused and need not be renewed. These substances can store from eight to 10 times as much heat, volume for volume, as water.

An experimental house at Dover, Mass., was designed by Eleanor Raymond and sponsored by Amelia Peabody. Its south-facing vertical window-collectors are in the attic, where there are heat-storage bins holding 470 cubic feet of the chemical mixtures that are capable of storing four million B.T.U. at 88-90° F. The house has a volume of 10,000 cubic feet, and its average daily winter heating requirement is 400,000 B.T.U. Hence there should be enough heat to keep the house adequately heated for 10 consecutive days. Data obtained last February showed that the collecting efficiency was 41 per cent of the total incident solar energy, ranging from 45 to 60 per cent on clear days. Ten days were cloudy, five of them consecutive. While the author states that considerable further research is required before solar heaters will be in general use, "The basic principles have been established and the trend of the development is clearly indicated."

## In the CURRENT JOURNALS

**The Moon's Path in the Sky, by C. H. Cleminshaw, *The Griffith Observer*, December, 1949. In December in Seattle one may have noted that the point of moonrise on the horizon changed by nearly 90° between new moon and full moon. Have you, too, been puzzled why the moon's position changes so rapidly? Dr. Cleminshaw explains it all.**

**The Satellite Rocket, by Willy Ley, *Technology Review*, December, 1949. "Much valuable scientific information might be supplied by an artificial 'Moon' which rocket engineers hope to launch into outer space some day."**

**Giant Follows Giant, by David O. Woodbury, *Technology Review*, December, 1949. "A 120-inch pyrex disc, left over from the 200-inch Mount Palomar instrument, will become a telescope in its own right." This is the story of the new reflector of the Lick Observatory in California.**

## *BON VOYAGE*

This month Dr. Bart J. Bok, associate director of Harvard College Observatory, leaves for South Africa on a 19-month tour of duty at Harvard's Boyden station at Bloemfontein, Orange Free State, South Africa. Dr. Bok, who is widely recognized for his studies of the Milky Way, will conduct researches into the center of the galaxy while he is in the Southern Hemisphere. Joining in the research there will be Dr. John S. Paraskevopoulos, resident superintendent of the station, Ivan R. King and Uco van Wijk, both Harvard fellows. Dr. Priscilla F. Bok will accompany her husband to South Africa.

Twenty-nine degrees south of the equator, the Boyden station is located where, during the best observing season, the galactic center in Sagittarius nightly passes directly overhead. The principal new instrument for the long-range observations will be the first large Baker-Schmidt type of telescope. Its two mirrors and correcting lens will combine to produce on one photograph star images of perfect quality over an area nearly equal to 100 full moons. Its clear aperture will be 32 inches and its focal length 120 inches. A 33-inch objective prism will be used with it.

The observing program will include taking of photographs in various colors of four selected key regions in the direction of the galactic center; Dr. Bok and Dr. Paraskevopoulos will be in charge of this part of the work. Mr. King, who has already been in South Africa for seven months, will measure photoelectrically colors and brightnesses of the faint standard stars of the project, while Mr. van Wijk will procure infrared spectra with the objective prism. When the observational work is completed by the fall of 1951, the astronomers will return to Cambridge, and many members of the Harvard staff will participate in the measurement and reduction of the plates.

A drawing of Comet 1843, which was one of the most spectacular objects ever seen.

# THE ORIGIN OF COMETS

BY OTTO STRUVE, *Yerkes and McDonald Observatories*

THOSE OF US whose lives have been mostly concentrated in the 20th century may have never experienced the tremendous excitement which is produced by the appearance of a great comet. But we have at least the right to expect that almost any night there may appear in the sky an object similar to the comet of 1882, which was plainly visible in full daylight and passed through the sun's corona at a distance of about 300,000 miles from the photosphere.

This comet was observed at the Cape of Good Hope until it appeared to touch the rim of the sun at 15:37 on September 17th. It then passed in front of the sun, but was not visible through the telescope. At 16:54 it left the disk of the sun and at 17:31 it passed through perihelion within the corona. Next, it was eclipsed by the sun, and finally it reappeared from behind the solar photosphere at 21:05. The velocity of the comet at perihelion was 480 kilometers per second. Its tail, though not the longest on record, stretched over a large part of the sky and was intensely brilliant. It was exceeded only by the Great Comet of 1843, whose tail extended over a distance of 300 million kilometers, or two astronomical units (one astronomical unit is the distance between the sun and the earth).

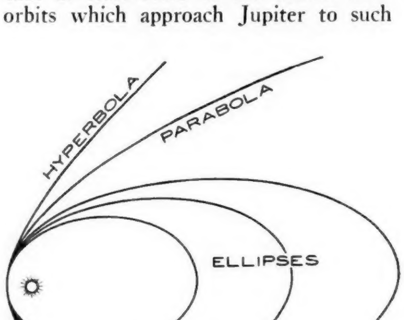
Yet, in spite of the absorbing interest which comets have always produced in the minds of men, we know little about their physical constitution and we have had until recently only a very superficial understanding of their origin.

In a recent paper published by the University of Leiden, Holland, Dr. J. H. Oort has presented a new and comprehensive theory of the comets. Already, more than a century ago, Laplace suggested that comets come from interstellar space. This theory was developed in detail by Schiaparelli and by Fabry in the 19th century, and more recently by N. Moisseiev in the Soviet Union. It fails because interstellar comets would be expected to possess large velocities with respect to the sun, such as are characteristic for objects moving in hyperbolic orbits.

It can be shown from elementary considerations that when the velocity of a comet at a given point in its path is less than it would be if it had fallen to this position from infinity, the orbit will be an ellipse. If the velocity is greater than a falling body would have acquired at the point of observation the orbit is a hyperbola, and if the velocity is precisely equal to that of a body falling from infinity the orbit is a parabola. It is obvious that interstellar comets, if they exist at all, must have random velocities which in some cases may be directed roughly in the general direction of the solar system. Such a comet would more often than not reach the vicinity of the sun with a speed that greatly exceeds the speed the comet would have had if it had fallen from a stationary position at a very great distance with respect to the sun. In this case a comet must move in a very open orbit, such as the hyperbola illustrated here.

It was first shown by Elis Strömgren in Copenhagen that there are on record no comets whose orbits were definitely hyperbolic in character before they came into the region of the planets. It is true that for some comets the observations have given values of the eccentricity greater than one, and by the concepts of celestial mechanics this means that they were moving in hyperbolic orbits while the observations were taking place; but this does not mean that these orbits were originally hyperbolic. In fact, Strömgren's computations in 1914 of the shapes of the paths of several comets, long before they approached the sun, indicated convincingly that the orbits had eccentricities smaller than one, and that only in the vicinity of the major planets the orbits became hyperbolic, and often remained so after the comets had left the solar neighborhood. Such comets are permanently lost and become true interstellar objects, whose probability of returning to our vicinity is exceedingly small. Strömgren concluded that all observed comets belonged to the solar system before they approached perihelion. His work has been extended by several later investigators, and always with the same conclusion: Those comets which appear to move with hyperbolic velocities when they are close enough to be observed had originally greatly elongated, elliptical orbits. But of those great comets that swept through the solar system a large fraction — actually eight out of 36 — were permanently lost from the system.

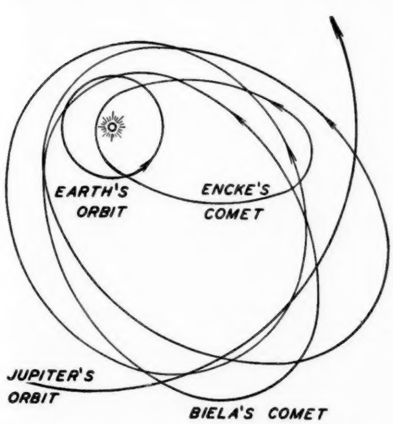
Because of the difficulty with Laplace's theory there has been a revival, in recent years, of another theory originally proposed by Lagrange, in which the origin of the comets is attributed to violent explosions on the larger planets, a process which is believed to be going on even at the present time. The principal contemporary exponent of this theory is the Russian astrophysicist Vsekhsviatsky, who maintains the view that at least some of the comets have orbits which approach Jupiter to such




**A comparison of ellipses, a parabola, and a hyperbola.**

an extent that it is possible they actually at one time occupied the same point of space. For example, the orbit of Comet Brooks II, according to Dubiago and Kamensky, at one time approached the orbit of Jupiter to about 0.01 A.U., or less than a million miles. Small changes in the orbit could have resulted in the actual crossing of the orbits at an earlier approach. Similarly, in the case of Comet Wolf I, a close approach to Jupiter in 1875 suggests that there could have been a moment when the comet was expelled from Jupiter as the result of an eruption. Vsekhsviatsky has made numerous computations in support of his theory, and has derived from the observed brightnesses of the comets a lifetime of the order of 70 years before disintegration due to mechanical or physical causes renders each object invisible.

This short lifetime has been criticized by N. T. Bobrovnikoff, who gave convincing reasons for believing that at least in some cases, for example in that of Comet Wolf I, the intrinsic brightness changed much less rapidly than was thought to be the case by Vsekhsviatsky. It has been established that the gradual increase in the size of astronomical telescopes has, paradoxically, brought about a tendency on the part of observers to estimate the brightnesses of comets as being fainter than was customary with small instruments. For example, the famous Comet Pons-Winnecke was easily visible with the naked eye in 1927, but could be seen only with difficulty through the Yerkes 40-inch telescope, because its head more than filled the field of view of the eyepiece. Despite this possible objection to Vsekhsviatsky's estimate, it is probably true that comets disintegrate rather rapidly even if their orbits are not greatly changed by perturbations from the planets. For example, the intrinsic luminosities of the short-period comets are several magnitudes fainter, on the average, than are those of the long-period comets.




**The orbits of a few comets of Jupiter's family, from "Astronomy," by Robert H. Baker.**

There is, however, one great difficulty in connection with the theory of Lagrange. The short-period comets which can be readily explained in this manner form only a small fraction of the 1,000 or more comets which have been recorded throughout historic times. Thus, the comets of Jupiter's family number approximately 42. Their motions are all in the same direction as are the motions of the planets, and the planes of their orbits do not differ greatly from the ecliptic. Their aphelia approach quite closely to the orbit of Jupiter. There can be no doubt that these comets are somehow related to Jupiter. But if they had resulted from an explosion on the surface of that planet, then it would be difficult to explain why the hundreds of long-period comets, or comets for which only parabolic orbits have been computed, show no preference for the plane of the ecliptic, being distributed more or less at random in inclination.

In order to explain this remarkable difference between the long-period comets and those of shorter period, Oort made use of Strömgren's work and added to it the results of later investigators. In 1927, G. Van Biesbroeck computed the definitive orbit of Comet Delavan, the famous war comet of 1914. The results of this work led to a hyperbolic orbit when the object was in the vicinity of the sun. By computing backwards and allowing for the perturbations of the planets, he found that Comet Delavan originally moved in an ellipse with a semimajor axis of 170,000 A.U. and a period of 24 million years. Similarly, for Comet Morehouse, he found that the original orbit was also a greatly elongated ellipse with a period of the order of half a million years.

Collecting all the information available, Oort found that there is a decided maximum of frequency among comets having a major axis of the order of about 150,000 A.U., which is not very different from the distance to the nearest star; but this does not mean that these comets are interstellar. On the contrary, Oort believes that they must be members of the solar system because they share the motion of the sun through interstellar space. How then can we explain this remarkable tendency of the comets to be moving in orbits which reach out beyond the confines of the domain of the planets to distances which are truly interstellar?

A few years ago, one of Dr. Oort's associates at the Leiden Observatory, Dr. A. F. F. van Woerkom, investigated in detail the effect of the perturbations of the planets upon different types of cometary orbits. His conclusions are highly technical, but he established that on the average a long-period comet, like Delavan's of 1914, once it has reached the relatively small volume of space in which the planets revolve around the sun, will be thrown out of its original elliptical path and will be found to pursue a new orbit. This may be one of short period, in which case the comet may temporarily become a member of Jupiter's family of comets — or it may be hyperbolic, in which case the comet is ejected from the solar system for all time.

**Comet Delavan 1914, photographed by E. E. Barnard on September 28th that year. Yerkes Observatory photograph.**

Suppose, then, that we have a cloud of comets revolving in different kinds of orbits with greatest distances from the sun of about 150,000 A.U. What are the conditions under which some of them may have perihelion distances of the order of one or two astronomical units, which would bring them close enough so that we could observe them? If we assume, to begin with, that the cloud of distant comets has a random distribution of directions with respect to the sun, then the overwhelming majority of the comets will never cross the small sphere with the sun at the center whose radius is two A.U., and will never be bright enough to be seen from the earth, but a small number will have velocities directed in such a way as to cross this small sphere. These are the comets which give rise to such phenomena as Delavan's, Morehouse's, or that of 1843. However, by an application of van Woerkom's computations it appears that the perturbations of the planets will be so large that nearly every comet which does come to within a distance of two A.U. will be "diffused" out of its original orbit and will either be converted into a short-period comet

or will be removed altogether from the solar system.

How then is it possible that there are any comets left within the outer cloud that have the required velocities and directions to bring them into the observable region? Since the orbital periods of the distant comets are all of the order of a few million years, it is certain that all those which originally could have come to within two A.U. must have done so long before the present era. One might ask whether the supply of comets is constantly being replenished by other comets whose original distances were even greater than 150,000 A.U. It is at this point that Oort makes one of his intuitive deductions: The cloud of comets cannot greatly extend beyond 150,000 A.U. because at very great distances the perturbations produced by the stars are large enough to disturb their orbits and remove them permanently from the solar system. It is this idea of perturbations produced by the stars upon the comets that is essentially new in Oort's treatment.

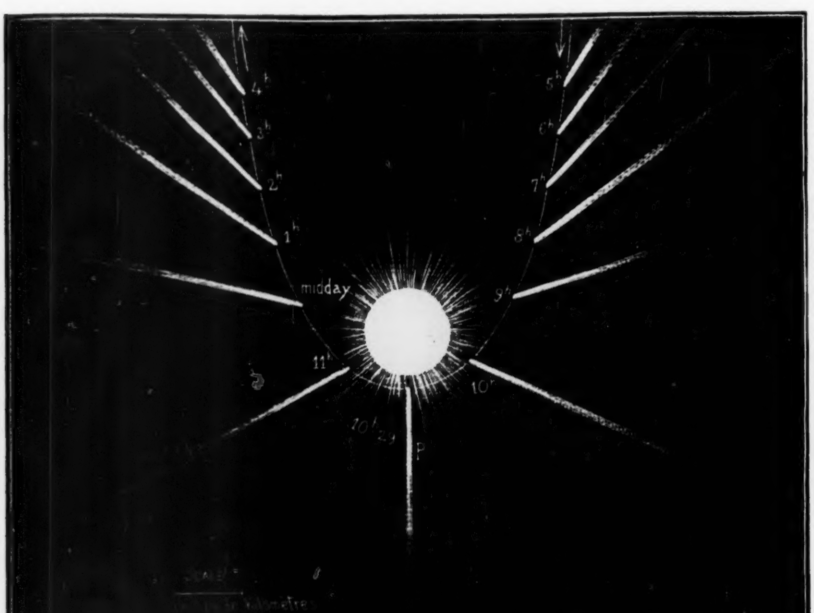
Not only do these perturbations set an upper limit to the size of the cloud of comets, but even within the cloud itself they produce appreciable changes in the motions. For example, at the critical distance of 150,000 A.U., where a comet spends most of its multimillion-year period, the stellar perturbations, though not on the average sufficient to remove the comet from the solar system, are nevertheless strong enough to alter the velocity in such a way that, if the original motion were in the plane of the ecliptic, the resulting motion would no longer be confined to it. All components of velocity will be distributed almost equally before such a comet has had time to approach the solar system.

This idea immediately provides an explanation for the continuous supply of comets from the outer cloud that can reach the critical sphere of two A.U. It is only necessary to suppose that within the outer cloud the number of comets is very great, perhaps one hundred billion. In that case there will always be new comets perturbed by stellar attractions in such a way that they may reach the small inner sphere and become visible from the earth.

This process will only stop after a considerable fraction of the $10^{11}$ comets have been thrown into the domain of the planets and perturbed by them in such a way that they must leave the solar system in hyperbolic orbits. It can be shown that for a lifetime of the solar system of three billion years no great progress has occurred in this slow diffusion of comets from the outer cloud, through the domain of the planets, and away into interstellar space. Oort's theory also shows why the inclinations of the orbits of the long-period comets have no relation to the plane of the ecliptic. On the other hand, he was able to show that comets captured by Jupiter, either through single large perturbations, or through the cumulative action of many small perturbations, will have substantially the observed distribution of major axes and will favor direct motion in contrast to retrograde motion.

The last and most exciting part of Oort's paper deals with the problem of the origin of the outer cloud of comets. It is improbable that bodies which are as large as those of comets could have been built up by the condensation of gas or dust at such enormous distances from the sun. Even if the planets are attributed to a condensing process, it is difficult to see how the comets could have been produced in regions where the original density was never much greater than that of interstellar space. Moreover, it is now regarded as probable that meteorites had the same origin as comets. Yet, the peculiar internal structure of a meteorite shows that it could not have been produced through any process of gradual condensation and accretion at low interstellar temperatures. This argument appears even stronger when we consider the evidence presented by Comet 1882, which moved through the solar corona. M. Minnaert has concluded that the nucleus of this comet could not have remained intact if the solid blocks of which it was composed had diameters of less than one-half kilometer. Apparently we must look for some mechanism that could have produced large chunks of matter, perhaps as large in some instances as some of the minor planets. There is no essential difference between comets, meteors, and minor planets except in physical characteristics which render the comets such spectacular objects, while the minor planets and meteors are relatively unexciting.

Oort suggests that the comets originated together with the minor planets and the meteors from the explosion of a planet-like body between the orbits of Mars and Jupiter. Those fragments that from the beginning had approximately circular orbits and those that were rapidly thrown into circular orbits remained stable members of the interior group of the solar system. Constantly exposed to the intense radiation from the sun, these objects lost their gaseous constituents and became minor planets and ordinary meteors. But some fragments had elliptical orbits and were therefore immediately subjected to large perturbations by Jupiter and other planets. Van Woerkom's theory suggests that the perturbations, in general, resulted in increasing the major axes of the orbits of these fragments, but the exact amount and the direction of the perturbing forces depended upon the circumstances of each approach. It can be shown that the diffusing action of the planets is such that all but about 1/30 of the orbits were converted into hyperbolas, and consequently 97 per cent of the exploded material was quickly lost to interstellar space. But since the perturbations cover a continuous range of values, there was an appreciable fraction, about three per cent of the total, which was thrown into orbits with major axes from 25,000 to 200,000 A.U.




**The Great Comet of 1843, which passed within 75,000 miles of the sun's surface, traveled on the timetable shown by the above diagram from Chambers' "The Story of Comets."**

These fragments formed the outer cloud of comets. Many of them would have been thrown into the cloud within a few years after the explosion. Hence, it is reasonable to suppose that these fragments retained much of their gaseous constituents. In fact, it is entirely possible that the solid stones or pieces of iron were embedded in a solid magma of ice, ammonia, methane, and the like, in the manner suggested recently by F. L. Whipple. At a distance of 100,000 A.U., the brightness of the sun would be 10 billion times less than that observed from the earth, and throughout almost the entire lifetime of such a distant comet, the sun would never appear brighter to it than Arcturus. It is therefore not surprising that within the cloud the original constitution of the exploded planet may have been preserved over several billion years. Once a comet finds itself in the outer cloud it does not return to the point in space where the explosion took place; perturbations by the stars will see to that. It is only when stellar perturbations finally distort the velocity of a distant comet to such an extent as to permit it again to return to the nucleus of the solar system that the heating action of the sun's rays can have a large effect. It is then that the comet develops a tail and for a time loses its gaseous material to interplanetary space.

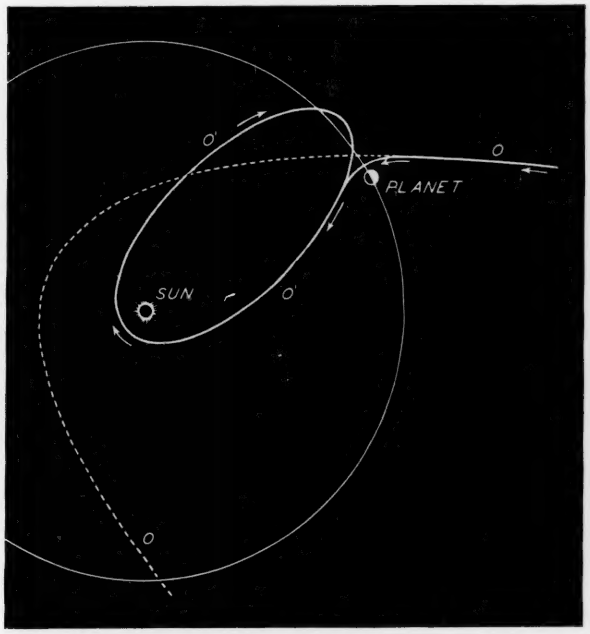
It is probable that at the present time the number of minor planets and other small fragments being thrown into long-period cometary orbits is very small; and it is impossible to make an estimate of the length of time that was required to sift out effectively the three groups of fragments: the 97 per cent that was quickly eliminated from the solar system; the comets thrown into the outer cloud; and the small remaining masses which, in the form of minor planets and meteors, revolve around the sun in stable orbits. (According to Russell, Dugan, and Stewart, the total mass of the third group is approximately 0.001 of the mass of the earth.)

If the original planet was comparable in mass to the earth, then material of about 1/30 the earth's mass, or possibly a little less, is still to be found in the cloud of the outer comets. Assuming with Oort that there are 100 billion comets within the cloud, we find that the mass of each comet must be of the order of $10^{16}$ grams, or 10 billion tons. But there are no reliable estimates of the masses of individual comets from observational data. Russell, Dugan, and Stewart concluded that it was safe to say that the mass of even a large comet is less than a millionth part of the mass of the earth. An estimate by Vorontzoff-Velyaminoff for Halley's comet was $10^{19}$ grams, or about 100 million times less than the mass of the earth. Altogether, it is reasonable to say that we have, for the first time, a theory of the origin of comets which accounts for most of the observed data. It is interesting that in some respects this theory is a revival or a modification of the old theory of Lagrange.

A large number of comets have escaped from the solar system and have become interstellar objects. The question arises whether other stars may not also help in producing a large number of freely moving comets which may, from time to time, enter the inner regions of our planetary system and then give rise to a truly hyperbolic comet. The fact that we have not yet observed such a comet does not mean that they do not exist. After all, G. Merton has recently listed only 22 comets for which computations have been made in the manner of E. Strömgren. Most other comets have been insufficiently observed to permit the computers to determine the forms of their orbits before they came into the domain of the planets.

If we assume that all stars produce interstellar comets at the same rate as the sun, then we can estimate that there are about $10^{12}$ interstellar comets per cubic parsec of space. Each comet will be perturbed in its motion by the neighboring stars, but from the time of its origin it will carry with it the velocity of its star of origin. Unless the cometary velocities become very greatly redistributed during the age of the galaxy they will retain, on the average, a distribution of motions that is similar to that of the stars. It seems from the work of S. Chandrasekhar that no very great approach toward "relaxation" has been reached. We can then make use of a formula derived long ago by J. H. Jeans and compute the interval of time between two successive "encounters" of the planetary domain of our solar system and an interstellar comet. The result is not much more than 100 years!

We should certainly be on the lookout. An interstellar comet is by no means impossible, and if one should appear it would almost certainly be a visitor from another star that is surrounded by a planetary system and has in the course of its lifetime witnessed the sudden disruption of one of its planets. Most recent theories of the origin of the solar system agree that the process of planet formation is not unusual in our galaxy. But it is another question whether the explosion of a planet, and the consequent diffusion of comets into interstellar space, is also a frequent occurrence in the universe.




**The manner in which the orbit of a long-period comet can be converted into one of shorter period. The labeling 0-0 represents the original orbit, which is changed to the ellipse 0'-0' and retrograde motion by a close passage to one of the major planets. Adapted from "L'Astronomie," by L. Rudaux and G. de Vaucouleurs.**

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## *IAU TO MEET IN 1951*

At the recent meeting of the American Astronomical Society it was announced that the executive council of the International Astronomical Union has decided to hold the next general assembly of the IAU in Leningrad, on invitation of the Soviet Union. The exact date has not yet been decided upon, but it will probably be in August of 1951.

The executive committee of the United States section of the union includes Dr. J. J. Nassau, of the Warner and Swasey Observatory, chairman; and Dr. Otto Struve, Yerkes and McDonald Observatories, American vice-president of the union. Dr. Nassau will collect information on the manner in which trips to Russia can be arranged and passports secured. It is expected that American delegates to the IAU assembly will get together to discuss plans at the meeting of the American Astronomical Society at Bloomington, Ind., in June of this year.

# TERMINOLOGY TALKS

J. Hugh Pruett

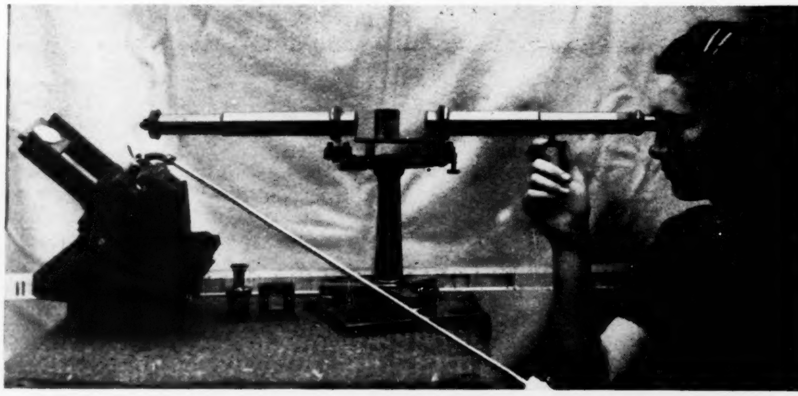
*Spectroscope (continued)*

The equipment for the study of the solar spectrum at the writer's Evergreen Observatory at Eugene, Ore., is illustrated here. A small table holds the instruments. Either a prism (in use in the picture) or a diffraction grating (seen beside the eyepiece on the table) may be used between the telescope tubes. At the left is a home-made coelostat, a device that is equatorially mounted and driven by a worm gear connected to a rod operated by the observer. The coelostat mirror reflects sunlight into the slit, which is at the left end of the collimating telescope. After the light passes through the prism the resulting spectrum is examined with the view telescope at the right.

When the instrument is in operation, the observer and all but the left end of the collimator tube are covered with a tenting of heavy black cloth. Also in the picture is seen a 42-inch stick on which is mounted a photograph of the solar spectrum. The tiny stellar spectroscope, attached to the eyepiece on the table, gives fairly satisfactory results on a 10-inch reflector when used on 1st-magnitude stars.

*Spectrograph*

As astronomers do nearly all of their observing of spectra by photographic means, they call the apparatus used for such work a *spectrograph.* The eyepiece of the view telescope is replaced by a photographic plate, and very long exposures may be taken to record the spectra of very faint stars. The telescope to which the spectrograph is attached serves as a light-gathering device. Thus large telescopes, such as the 82-inch McDonald Observatory reflector in Texas and the 69-inch Perkins Observatory reflector in Ohio, are used chiefly for spectrographic work. Their great light-gathering power permits astronomers to obtain the spectra of very faint stars or to use high dispersion on the spectra of brighter stars. For this purpose, of course, the 200-inch telescope is unsurpassed, and this is one of the principal reasons for building that instrument.



**The simple apparatus used at the Evergreen Observatory permits easy observation of the spectrum of the sun.**

*Diffraction Grating*

As mentioned above, a *diffraction grating* may be used instead of a prism to disperse light into its component wave lengths. Such a grating is simply a series of fine lines ruled close together and parallel to each other. When light is either reflected from or transmitted through such a grating it is dispersed into colors, as may be noted by the rainbow effects produced by light reflected from a phonograph record, which forms a rough grating. For precise optical purposes and astronomical uses, gratings with 10,000 or 15,000 lines to the inch are often required. The ruling of even small gratings of this quality is a very difficult art.

A grating produces several spectra, of different *orders* and dispersion. To get high dispersion with prisms, astronomers often use several of them in a series.

**A spectrograph attached to the 69-inch reflector at the Perkins Observatory, Delaware, Ohio. It employs two prisms in tandem to give moderately high dispersion for stellar spectra. The astronomer is Dr. J. A. Hynek, McMillin Observatory, Ohio State University. Photograph by Robert E. Cox.**

*Continuous and Emission Spectra*

Certain sources of light give off all colors from the deep red to the extreme violet. When viewed with a spectroscope, the multicolored light appears as a continuous band of colors, each gradually blending into the next. It is a veritable rainbow, but spread out through a far wider visual angle than the mere two degrees of the rainbow in the sky. This type of color band is known as a *continuous spectrum,* and it is produced by a luminous solid, a glowing liquid, or a hot, dense gas. The glowing filament in an electric light bulb gives such a spectrum.

Should the radiation originate in a luminous rarefied gas, however, the spectrum is not continuous, but is composed of a few or many bright lines, of various colors and with dark spaces between them. A neon street sign gives such a spectrum, as do also materials vaporized in a gas flame. As we noted last month, sodium vapor gives off a

yellow light, which a good spectroscope shows to be composed principally of two yellow lines close together. Lithium gives two prominent lines; calcium, eight; and barium, 16.

Two elements may both give yellow lines, but when their spectra are compared the lines will be found at different places in the wave length scale. Of the thousands of spectral lines known for the various elements, rarely do two appear at the same location. The fact that each element has its own characteristic spectral lines makes it possible to analyze the constituents of a mixture of various types of materials. The substances must be vaporized to do this, but even very small samples can be analyzed chemically in this manner. *Bright-line spectra* are also known as *emission spectra.*

### ASTRONOMICAL LEAGUE NOTES

The Astronomical League **Bulletin** for January reports on seven problems that were discussed at the October meeting of the national council: complete analysis of the observing problem to be presented at the Wellesley convention; plans to urge the appointment of an observing chairman or committee in each AL member organization; the observing manual; membership in observing societies by AL member organizations; a speakers list; a central information clearinghouse; materials and instructions for specialized astronomical instruments.

The Texas Astronomical Society has joined the league, its membership totaling 32, including a few juniors. The Brazilian Society of Friends of Astronomy hopes to join the league as soon as United States funds can be secured. The National Bureau of Standards called upon the National Capital Astronomers for assistance in observing the Geminids, in order to co-ordinate visual observations with radar records made at Sterling, Va. The program was planned for four nights, but the sky became overcast about midnight of the first night and remained so for the rest of the shower.

The proceedings of the national convention at Cleveland last year are now available: 34 mimeographed pages for 50 cents. Order from the executive secretary, Grace C. Scholz, 110 Schuyler Road, Silver Spring, Md.

### CONVENTION OF WESTERN AMATEUR ASTRONOMERS

Announcement has been made by the chairman of the convention committee, David P. Barcroft, of Madera, Calif., that by invitation of the Peninsula Astronomical Society the 1950 conference of western amateur astronomers will be held in Palo Alto, Calif., sometime during August. Chairman of the local convention committee is H. A. Wallace, 2139 Buchanan St., San Francisco 15, Calif.

The 1950 officers of the Peninsula A.S. were recently elected: H. C. Schepler, Stanford Village, president; Arthur W. Orton, San Bruno, vice-president; Mrs. Dorothy R. Rossiter, Menlo Park, secretary-treasurer.

# *Amateur Astronomers*

## League 1950 Convention to be Held at Wellesley

WELLESLEY, Mass., is the site of the national convention of the Astronomical League this year, on the weekend July 1-4. The regional convention of the Northeast region will be held concurrently, and the region is to conduct the convention, as provided in the by-laws of the league.

Very favorable arrangements have been made with Wellesley College for delegates to occupy dormitories and to take all meals on the campus. The total cost for three nights is expected to be very reasonable, and as soon as final arrangements are made reservation information will be announced. The principal activities of the convention will begin Saturday evening, July 1st, and extend to the morning of July 4th, closing with a field trip to the Oak Ridge station of Harvard Observatory at Harvard, Mass.

At Harvard's Cambridge headquarters open house for early arrivals to the convention will be held on Saturday afternoon preceding the official opening of the convention. There will also be opportunity to visit the new Boston Museum of Science site and the points of historical interest in Boston and vicinity.

In addition to six sessions for talks by amateurs and for the discussion of amateurs' problems, there will be a unique opportunity for delegates to get firsthand instruction in observing. Weather permitting, a school for observing will be held on each of the three convention evenings, under the guidance of leading amateur observers. The Wellesley campus is the home of Whitin Observatory, where on Saturday night there will be open house and an opportunity to observe with the 12-inch refractor. That same evening Dr. John C. Duncan, director of the observatory, will give a special showing of astronomical pictures.

Sunday evening will be featured by a panel of experts from Harvard Observatory and other institutions, and on Monday there will be a lecture by an invited speaker.

This promises to be one of the coolest of summer conventions, as the Wellesley grounds are green and wooded. Delegates will be able to take daily dips at the college beach on Lake Waban.

The convention chairman is Charles A. Federer, Jr., Harvard College Observatory, Cambridge 38, Mass., and chairman of the program committee is Rolland LaPelle, 54 Fernleaf Ave., Longmeadow 6, Mass. Those wishing a part in the program or needing to obtain information in advance of publication should communicate with either of these persons. The convention is being held under the joint invitation of the Bond Astronomical Club, the Amateur Telescope Makers of Boston, and the American Association of Variable Star Observers. The local committee is made up of members from each of these societies.

CHESTER COOK
Chairman, Northeast Region
Astronomical League

### THIS MONTH'S MEETINGS

**Buffalo, N. Y.:** At the meeting of the Amateur Telescope Makers and Observers of Buffalo, on Wednesday, February 1st, Eugene Wallmeyer will outline the contents and use of the "Graphic Time Table of the Heavens." The program for the February 15th meeting will be announced. Meetings are held at the Buffalo Museum of Science at 8 p.m.

**Cambridge, Mass.:** The Bond Astronomical Club will hear a talk by Dr. Cecilia Payne-Gaposchkin, Harvard College Observatory, on "Stars That Pulsate." The meeting is at the observatory, 8:15 p.m., on Thursday, February 2nd.

**Chicago, Ill.:** The Burnham Astronomical Society will meet on February 14th at 8:00 p.m., in the Chicago Academy of Sciences auditorium. Following a period for observing, members will participate in reminiscences of S. W. Burnham (1838-1921), after whom the society is named. Then a sound motion picture on atomic energy will be shown.

**Dallas, Tex.:** Jack Kucera will speak on "Galaxies, Nebulae and Star Clusters" at the February 27th meeting of the Texas Astronomical Society, in the Dallas Power and Light auditorium, at 8 o'clock.

**Geneva, Ill.:** At the February 7th meeting of the Fox Valley Astronomical Society, in the Geneva City Hall at 8 o'clock, William Siekman will speak on "Binary Stars."

**Indianapolis, Ind.:** Russell Sullivan will discuss "The 'Phaenomena' of Aratus" at the meeting of the Indiana Astronomical Society, in Cropsey Hall on February 5th, 2:15 p.m.

**Lorain, Ohio:** The February 13th meeting of the Black River Astronomical Society will be held at Clearview High School at 7:00 p.m. William A. Mason will speak on "Testing Technique."

**New York, N. Y.:** Dr. I. M. Levitt, of the Fels Planetarium, will speak on "Mysteries of Science," at the February 1st meeting of the Amateur Astronomers Association, 8:00 p.m. in the American Museum of Natural History (77th St. entrance). The winter weekend field trip of the society to Peekskill, N. Y., is scheduled for February 17-19.

**Pittsburgh, Pa.:** On Friday, February 10th, at the Buhl Planetarium at 8:15 p.m., David A. Batchelor will present "A Rocket Tour of the Solar System," for the Amateur Astronomers Association.

**Portland, Ore.:** "Electronics in Astronomy" will be discussed by Cecil Post at the February 1st meeting of the Portland Astronomical Society, 7 o'clock in the Central Public Library.

**Washington, D. C.:** The National Capital Astronomers will meet at the Commerce Department auditorium on Saturday, February 4th at 8 p.m. Dr. James B. Edson, of the Office of Chief of Ordnance, will lecture on "The Atmosphere of Venus."

# SEEING--II

By Dorrit Hoffleit

*Harvard College Observatory*

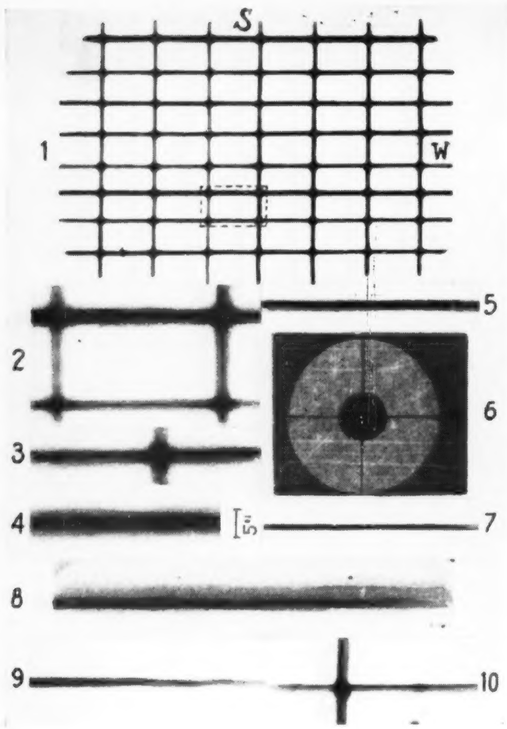



**Fig. 5. Traces of stars across the 60-inch Cordoba reflector plates to study inversion layer spectra. 1. Traces of Canopus enlarged three times. 2. Scintillating and inversion layer spectra, with the zero order of theoretical width. 3. Pulsating spectrum. 4. Pulsating image without fine structure. 5. Dancing of the zero order. 6. Shadows on the mirror, 1/25 second. 7. Good seeing, instantaneous cross section 0.7 second of arc. 8. Complicated pulsating and scintillating. 9. Dancing of the orders. 10. Asymmetric traces. Engraving courtesy "The Astronomical Journal."**

IN ORDER to investigate the periods of the variations of the seeing effects discussed last month, Enrique Gaviola trailed his telescope. The fastest rate for trailing was such as to give the image of a star a maximum speed of about 30 centimeters per second across the photographic plate. This enabled him to get trails of 1st-magnitude stars even on relatively poor nights. The trails show conspicuous variations which Gaviola interprets in terms of inversion layer spectra. The instantaneous image of a star should be a diffraction spectrum whose dispersion (length) would depend on the wave length, *L*, of the inversion layer. If this is, say, eight centimeters, then the separation of the first-order shadow bands would be 0.85 second of arc for light of 0.000035 centimeter and 1.20 seconds of arc for light of 0.000048 centimeter wave length. These values are common wave length limits in ordinary celestial photography. Here the instantaneous length of the star image should be 0.35 second of arc. The distribution of light in the spectrum depends on the amplitude and shape of the inversion layer waves while the length of the spectrum depends on the wave length, *L*. By trailing his telescope Gaviola was able to determine how long any given pattern lasted.

In many cases he found several orders of spectra present, up to 11. Fig. 5 shows several examples of trails of Canopus. Picture 2 is an enlargement of the indicated section of Picture 1. One horizontal mesh corresponds to less than 0.02 second of arc. In the lower trace of Picture 2 a fine line is seen in the middle of a hazy band. The fine line may be considered as the "zero order." It has a diameter which is nearly the theoretical image diameter. This lasts about 0.015 second — the interval of visually almost-perfect seeing — not quite perfect because of the wide dimmer band surrounding the fine line.

Many of the trails in Fig. 5 are as much as five seconds of arc wide and many are asymmetric in density. It is not surprising that the trail structure should be complicated and asymmetric if one keeps in mind the possibility of several inversion layers occurring simultaneously but varying more or less independently of one another.

Steadiness of seeing, as indicated by the persistence of any particular fine structure in the trails, lasts only from thousandths to hundredths of a second. Hence the shadowgrams Gaviola obtained with exposures of 1/25 to 1/50 second (Fig. 4) are usually too long to show instantaneous conditions. The observed fine structure is more detailed in the east-west than in the north-south trails, as would be expected if the inversion spectra are vertical. (For pictures of Mars and the sun, Gaviola recommends taking many exposures of less than 1/50 second, from which only the good ones are to be chosen.)

Among possible applications of his studies Gaviola mentions three: setting up impartial scales for recording seeing (to supplement or replace present subjective scales), which can be utilized in the selection of observing stations; meteorological studies of the inversion layers as such; and astrometric studies of double stars. Measurements of the separation of the trails of double stars might lead to results having an accuracy comparable with the theoretical resolving power of the telescope. Incidentally, we note with interest that the amateur group, Asociacion Argentina, reported to the Astronomical League that they are collaborating with the National Observatory at Cordoba making observations of selected double stars with a view of making a survey of atmospheric transparency at several points in Argentina, and that observatories in Chile and Uruguay are also collaborating.

A comparison between Gaviola's star trails and natural meteor trails may be of interest. Numerous trails in the Harvard meteor collection show structure comparable with the variations shown in Gaviola's star trails. The speeds of the meteor images across the plates range from, say, one to 300 centimeters per second as compared with Gaviola's 30 or less. Some of the slightly "sinuous" meteor trails bear some resemblance to Fig. 5, Picture 9 — where two "first-order spectra" are described as dancing around a relatively steady "zero order." There has been considerable discussion of the meteor trails: are the waves and flickering due to meteoric phenomena, to something about the air, or to vibrations of the camera?

Assuming Gaviola's data as representative, we should expect apparent "vibrations" in meteor trails due to inversion layers, with fluctuations having an amplitude of the order of five seconds of arc superposed on trails having normal widths equal to the theoretical image diameters. Most of the Harvard meteor trails were obtained with lenses giving theoretical image diameters of a few seconds — small enough for the detection of only the larger oscillations in seeing. In the past a few of the most pronounced sinuous effects have been studied in detail. One trail obtained at Tucson with the 36-inch reflector (theoretical image diameter of about a quarter of a second) showed both sinuosity and density fluctuations, apparently independent of one another. The density fluctuations corresponded to time intervals averaging about 0.005 second (from 0.001 to 0.03). At the time, the fluctuations were assumed to be associated with missile rotation. Maybe it was seeing? The amplitude of the sine wave was less than the width of the trail; the width, however, was 14 seconds, greater than one might expect from normally good seeing.

Most of the density variations found on Harvard meteor trails are far too conspicuous to be attributed to seeing; but the interval of the fluctuations, of the order of 0.004 second, is the same as some of the periods of seeing fluctuations. The sinuous trails usually find a mechanical interpretation. For example, one showed an amplitude of 0.12 to 0.14 minute of arc with a period about 100 times as long. In 1940, Dr. Fred L. Whipple conducted a stroboscopic test on the camera and found that the driving motor of the camera imparted to it a vibration having a period of 1/20 second. This fully accounted for the sine-wave meteor trail.

What are the characteristics of the drive that Gaviola uses on his telescope to obtain the star trails? How fast do the vibrations when starting and stopping the drive dampen out? He had one example of a vibrating trail, obtained when the telescope was halted for about a second in the process of changing the speed. Are such vibrations still present to a lesser degree in some other trails, and if so, how do the residual vibrations affect the interpretation of seeing? As the scale of the Cordoba plates is large, the same amplitude of vibration in millimeters on the plate corresponds to a much smaller value in angular star position than on the small-scale plates taken with the Harvard patrol cameras.

The Harvard solar stations are also working on problems of seeing as well as on the important related topic of sky brightness. Theirs may well be of appreciably greater magnitude than Gaviola's problem; for daytime fluctuations are often conspicuously great. Dr. John W. Evans, of the High Altitude Observatory at Boulder, Colo., has developed several schemes for evaluating seeing in connection with solar photography. One test he obtains from a picture of the solar limb taken with a 4-inch refractor. This is compared with a similar image of an artificial sharp-edged sun. Evans' "meter" consists of a device for comparing the picture of the true sun with that of the artificial sun thrown out of focus until its edge matches the true sun's image in fuzziness. The out-of-focus scale is the seeing scale, and it is good over a range of about 20 steps. Evans reports that two types of "edges" are observed: "fuzzy" and "jagged." Tentatively these are interpreted as indicating the relative heights of the inversion or disturbing atmospheric layers, disturbances at long distances giving sharp, jagged edges while those nearer by merely make the image fuzzy.

Another of Evans' devices, strictly a sky-brightness meter, was described in 1948 in the *Journal* of the Optical Society of America (*38*, 1083, 1948). He uses a miniature Lyot-type coronagraph for comparing a region close to the sun with an image of the sun seen through a wedge and filter (Fig. 6), the wedge being adjusted to give equality with the sky background. The test of good seeing for coronal spectra, he states, is that the sky background should be much less than one 250-millionth as bright as the sun.

In Fig. 6, the disk at the left occults the three-millimeter aperture at *A*, 100 centimeters away. The second occulting disk is in the focal plane of the first lens and large enough to intercept the somewhat out-of-focus image of the brilliant (diffracted) edge of the first occulting disk. *E* is an aperture diaphragm concentric with the exit pupil, where *A* is imaged by the eye lens.

The surface of the second disk toward the observer is painted diffuse white to reflect direct sunlight that has passed through the optical wedge. The observer sees the image of the sun surrounded by the sky.

In conclusion, it is of interest to summarize the various ways in which seeing is important to different observers. We have found that parallax observers are primarily concerned to have the unavoidable meanderings of all the star images on a plate parallel (as well as small); for they must avoid differential errors between the various stars in the same field. Observers of Mars and the sun are chiefly interested in a "fixed" image in order that their photographs may show the utmost detail. Meteor observers cannot be choosy and repeat exposures; therefore, they must ascertain how much of the detail they find can be attributed to the meteor, how much to seeing, and how much to the idiosyncrasies of the equipment. And as for surveying, airplane spotting, and other daytime observations, we can think of many problems. What may not seeing in its various aspects have to do with the identification of those scary "flying saucers"!

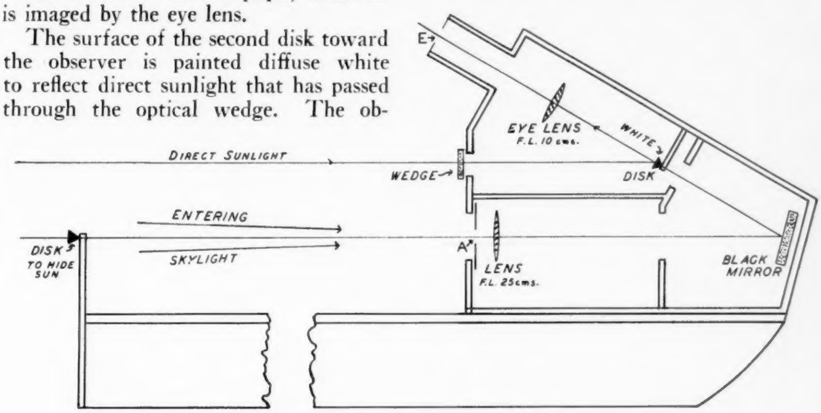



**Fig. 6. A schematic diagram of Evans' sky photometer.**

## *SCHMIDT LENSES IN MASS PRODUCTION*

Before the war there were scarcely 50 lenses of the Schmidt correcting type in the world, all used for astronomical instruments. They had each required weeks to months to make because of their complicated curved surfaces. The high-speed Schmidt systems were in great demand during the war, and it is now known that both American and German optical men worked night and day to find a means for producing them rapidly. Science Service reports that Dr. E. D. Tillyer, research director of the American Optical Company, has recently received a patent on a method he devised and which was used in wartime instruments.

He used a special mold having the proper curves, placed a ground and polished sheet of optical glass on the mold. Heating of both together gave one side the proper figure, and the other side could be reground and polished as desired.



## *THE RUMFORD MEDAL*

In recognition of his contributions as a physicist, engineer, and astrophysicist, Dr. Ira S. Bowen, director of the Mount Wilson and Palomar Observatories, was awarded the Rumford medal of the American Academy of Arts and Sciences in Boston on December 14th. His most outstanding achievement was his identification of the puzzling "element" provisionally called "nebulium" from its occurrence in the spectra of gaseous nebulae. Through Dr. Bowen's analyses, "nebulium vanished into thin air," being identified as highly ionized oxygen and nitrogen. At the time of receiving the medal, Dr. Bowen addressed the academy on the progress of work with the 200-inch telescope.

# BOOKS AND THE SKY

## THE CONQUEST OF SPACE

Paintings by **Chesley Bonestell**; text by **Willy Ley.** Viking Press, New York, 1949. 160 pages. $3.95.

IT IS PROBABLY the attractive paintings by Bonestell that give **The Conquest of Space** its greatest selling power. These are powerfully drawn to stimulate the imagination and enhance the layman's yearning for space travel. Their well-simulated photographic quality might even lead the casual buyer into the temporary impression that these "scenes" were observed rather than that they are products of mental deduction from relatively sparse facts.

Willy Ley writes with an easy conversational style. Anyone who has been present at a V-2 "shoot" at White Sands Proving Ground will relive his first impressions on reading the beginning of the first chapter, "Four, Three, Two, One . . . Rocket Away!" This is followed by a brief description of the orbits of rockets and solar satellites.

In discussing rocket trajectories, it is remarked that "the 'real' trajectory in the mathematical sense, begins when a 45-degree tilt is completed." A page later it becomes clear that the 45° is necessary only to achieve maximum range. But despite a few such slips, the lay reader should get a very good general impression of the problems involved in long-range rocket flights, and an appreciation of the purpose of multistage rockets and of the difference in function between jet planes and winged rockets. Orbital rockets, according to Ley, are a definite possibility; they would require a velocity of about five miles per second — only three times the highest velocity yet achieved. When this has been accomplished, he believes it will be followed by a manned station in space.

This section on terrestrial rocketry is followed by the first collection of paintings showing how the earth would look from various altitudes up to 4,000 miles. Most of the pictures are readily plausible. The one from 500 miles, showing auroral curtains, may however arouse debate on the aurorae. Such curtains usually occur at altitudes under 200 miles, whereas the impression one gets from Bonestell is that they are much higher than the rocket. On the other hand, Stoermer has reported **diffuse** aurorae beyond 600 miles.

The moon, of course, is the first anticipated extraterrestrial target. Ley brings in entertaining references to the "prehistory of space travel": moon hoaxes as well as the serious discussions of a century ago on the possibilities of life on the other side of the moon. There is interspersed considerable description of the lunar surface. To some of the facts we might take exception, for instance, that the rays emanating from Tycho, Copernicus, and Kepler are "not very wide but up to a hundred miles in length." From well-known textbooks we learn that the rays extend in some cases a distance of many hundred miles and are usually from five to 10 miles wide.

Reported changes on the moon are taken at face value — not as they should be as observational data desperately in need of independent verification. Such reported changes, to be sure, lend added incentive to space travel for the purpose of obtaining firsthand information to replace present inferences.

The paintings of close-ups on the moon have for the most part a familiar aspect; they are not greatly unlike Howard Russell Butler's beautiful lunar landscape in the American Museum of Natural History in New York. The addition of the spaceship, ready for its return trip with its service crew of a half a dozen earthmen, is the new touch of optimism.

The chapter on the "Solar Family" gives general information on the physical properties of the planets and their orbits. The possibilities of space travel to Mars and Venus are discussed, but in less detail than in some of Ley's other publications. More in keeping with the purposes of the joint authorship of **The Conquest of**

Space, there is considerable description of what is known of atmospheres or surface features, particularly of the inner planets. From the facts collected in the text, readers might be a bit surprised at the wealth of detail the artist renders, especially on Jupiter, whose solid surface is said to be ice (frozen water, $H_2O$; ammonia, $NH_3$; and methane, $CH_4$) with "a deep atmosphere of clouds of methane and ammonia crystals." The cloud layer is all that has ever been observed. The accompanying painting shows theatrically steep cliffs, with red hydrogen flames and falls of "lava" pouring into a liquid ammonia lake.

The final chapter, "Vermin of the Skies," gives a delightful account of the asteroids, "male" and "female" — probably as good a rendition as the average layman is apt to encounter. We disagree, however, that a "Moon Equilateral" (a body moving so as always to form an equilateral triangle with the earth and moon) would leave a trail on our celestial photographs that would be taken for a meteor trail.

While we thus find a few minor details with errors in them, the overall effect of **The Conquest of Space** should be beneficial to the layman; for what he finds here is both informative and stimulating to the imagination. If he compares the pictures carefully with the text he should be able to decide just how much he sees is proven fact, and how much the product of induction which may be subject to future rectification. The book is a plea for "third era" astronomical investigators to supplement their telescopic observations with space travel, just as the second era telescope users improved upon the naked-eye observations of their predecessors. While many of the technical problems of interplanetary rocketry look promising of eventual solution, too little mention is made of the problem of human survival on or between other worlds than ours.

DORRIT HOFFLEIT
Harvard College Observatory

### BASIC OPTICS FOR THE SPORTSMAN

**Earle B. Brown.** Stoeger Arms Corporation, New York, 1949. 259 pages. $4.00.

A SUITABLE optical instrument for use in sports, one that is in reach of the average man's pocketbook and that will satisfactorily handle his problems, presents a dilemma to the layman every day. In this book varied information from manufacturers of optical equipment for sports is gathered together with an introduction to optics, all in such a manner as to present a valuable reference book for the sportsman who wishes to know just what he can expect from an instrument he purchases.

Part I on "Principles of Optics" is well written and does much to introduce the beginner to the terminology of optics as used by the technician, which, as the author points out, is often distorted in meaning by the laity.

The optical principles of Part I are skillfully applied in Part II to optical instruments, "those whose function it is to aid the human eye in observing objects." Here the uninitiated can find just how and why his rifle scope, binocular, telescope, camera, or microscope operates.

The third part on the care and selection of instruments will be most useful in helping the sportsman decide what instrument is most suited for his needs, and, if the instrument is not new, what malfunctions to look for so he can reject the equipment if such imperfections are present.

The modern photographs and excellent two-color diagrams add much to the appearance of a fine printing job. However, it is unfortunate that the sketches throughout the book are of such poor execution and somewhat detract from its otherwise high quality. A glossary of optical terms and a good index help the reader.

Although not in the class of a popular work on optics, **Basic Optics for the Sportsman** is a handy reference for the amateur when he is requested to look up information on some optical instrument for a friend going into sports. This volume should also be a valuable addition to one's optical bookshelf, and it will do much to fill a vacancy that has existed in optical literature.

ROBERT E. COX
Stamford Museum

### NEW BOOKS RECEIVED

MEASURING OUR UNIVERSE, *Oliver Justin Lee*, 1950, *Ronald Press.* 170 pages. $3.00.

A volume of the Humanizing Science series that describes methods and machines for measuring things from the very small to the very large, with considerable emphasis on astronomical research processes.

# GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

## TWO SIMPLE SLIDEOFF-ROOF OBSERVATORIES

WOODEN CONSTRUCTION lends itself to easy fabrication for an amateur's observatory, and the resulting building may be made to blend into its surroundings in a pleasant manner. One of the observatories pictured here was built by Captain William H. Galbraith, USN (Ret.), in his spare time. The other was constructed for L. L. Rice to house a 7-inch refractor used for many years by the late Reverend T. C. H. Bouton. Here are the descriptions sent by these men.

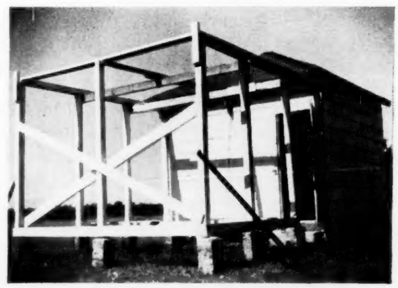
I claim nothing new in this structure other than the utilization of the track extension for a lath house, thus somewhat mollifying my wife, who was not at all enthusiastic about the placing of a "shack" in our driveway, in front of the house. This was also the reason I used bungalow-type siding and a low-pitched, shingled roof in order to make the building harmonize as much as possible with our house. I might also have added windows with blinds, but this would have reduced the available wall space, and this is none too great with a 10-by-10-foot floor area.

The observatory houses a 5-inch refractor made by John Mellish, of Escondido, Calif. The telescope is mounted on extra heavy 5-inch steel pipe, sunk three feet deep in concrete, and the floor is of cement. The roof, which I tried to make as light as possible, is made up on four trusses of 1 by 4 material, assembled on a pair of 2 by 4's 10 feet long, laid flat and slotted to receive eight sheaves, 3" in diameter, four on each side.

I bought these sheaves at a war surplus store for 30 cents each. They are surplus aircraft control sheaves made of duralumin and fitted with self-lubricated bearings. Their track is of ¾-inch galvanized T-bars, inverted and screwed directly to 2 by 4 sleepers. I was afraid that these sheaves might prove too soft to stand up to this sort of service, but after several weeks of operation I find no sign of wear. The roof rolls so easily that I even find it necessary to latch it to prevent the strong afternoon westerly winds from blowing it out over the lath house. The low wire seen just above the roof is temporary, and will be moved.

With the exception of the lath, shingles, concrete, and about 25 per cent of the redwood siding, all the material was salvaged from a recent remodeling job on my house. As a result, I was able to complete the job for an outlay of $120.

WILLIAM H. GALBRAITH
7820 Montana Ave.
Lemon Grove, Calif.

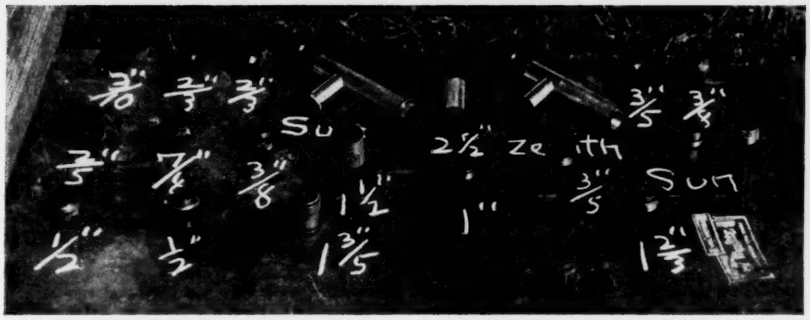


**L. L. Rice's observatory, Ware Neck, Va.**

The observatory is located on the front lawn of my home, which faces south, about 100 feet from the Ware River, at Ware Neck, Gloucester County, Va. The "river" is really an estuary of Chesapeake Bay. For an ocean-level region the location is unusually good. The lawn with a 1,000-foot frontage on the water affords a perfect field for observation from the southeast to the southwest. The view to the north is also unobstructed, but the sliding roof cuts off the eastern view about 43° above the horizon, and trees cut off as high as 40° toward the west.

The building is 13 feet square and seven feet high from the floor to the bottom of the sliding roof. The latter runs on eight solid-rubber, ball-bearing wheels and is operated by four double pulleys. The building is wood, covered with heavy felt

**The observatory of Captain William H. Galbraith at Lemon Grove, Calif. The roof slides over a lath house during observing periods.**




The eyepieces used with the Brashear refractor at L. L. Rice's observatory.

paper and white asbestos-cement siding. Tacked on the inside walls are star charts, and scores of reproductions showing the sun, moon, planets, nebulae, clusters, and the like.

The 7-inch Brashear objective and complete outfit is that of the late Reverend Bouton, one of the best-known variable star observers of the world. The barrel is of metal, black, seven feet long, and a splendidly made brass eye-attachment accommodates the focal length of about 100 inches. One limitation of the equatorial mounting is that it must be operated manually, but it is so perfectly balanced by counterweights on the axes that in all positions it remains steady. Numerous tests with magnifications from about 38 to 320 indicate an objective of practically perfect definition. This, of course, is to be expected of a Brashear glass.

The illustration shows an unusual "galaxy" of eyepieces ranging in focal length from 3/10 to 2½ inches. The sun prism has three oculars: one blue, one yellow, one grayish.

The telescope is set on a concrete base, which is sheathed by tongue and groove material five feet 10 inches above the floor, and buttressed by four strong supports.

A cordial invitation is extended to nearby and traveling amateurs to inspect this instrument, the former owner of which made tens of thousands of observations of variable stars as a member of the AAVSO.

L. L. RICE
Ware Neck, Va.

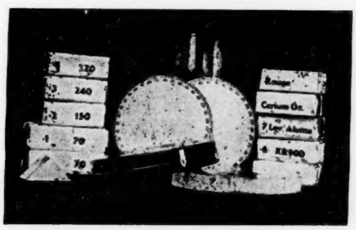
## GEAR-TRAIN SIMPLIFICATION

There must be many amateur telescope makers who would like to have a motor drive on their telescopes. But when they figure out a gear train that will give one revolution in a sidereal day, they come out with gears with such a large number of teeth that they have difficulty getting them made.

In the first place it is a mistake to make a telescope drive to give one revolution per sidereal day, because the refraction of the earth's atmosphere causes the stars to appear to move slower than the earth turns. While the earth turns 15 degrees, a star that was at the zenith will appear to have moved about 15½ seconds of arc less than 15 degrees. This amounts to a little over one second of time per hour. Of course, the farther from the zenith the telescope is pointed the slower a star will appear to move, so if a telescope drive were to follow a star perfectly it would require a variable rate drive. But a fairly good compromise can be made by adding 26 seconds to the length of a sidereal day, making 23 hours, 56 minutes, and 30 seconds of mean solar time.

With this figure it is much easier to find a gear train without going to large numbers of teeth. If one is using a



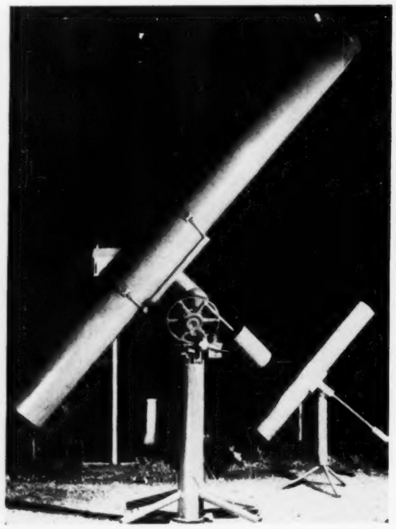




synchronous motor with an enclosed gear train so that the final shaft has a speed of one revolution per minute, then either of the following gear trains may be used:

1. A four-thread worm driving a 34-tooth worm gear and a single-thread worm driving a 169-tooth worm gear.
2. A 20-tooth pinion meshing with a 170-tooth gear and a single-thread worm driving a 169-tooth worm gear.

PAUL B. SWEGER
R.R. 3, Box 29
Rockford, Ill.



Russell W. Wilkerson's telescope.

### A 12½-INCH NEWTONIAN

My 12½-inch Newtonian reflector has an electric drive in right ascension. A sidereal right ascension dial is set to the correct star time and afterwards runs with the clock drive so that right ascension is set directly by means of index marks that rotate with the equatorial shaft. This makes setting much simpler for any object which might not be visible to the unaided eye.

The optical parts are mounted in an all-steel tube. The mirror is of 124 inches focal length, figured to the very close limits of a perfect parabola. The long focal ratio gives wonderful definition on the planets and the moon, and it is also splendid for star clusters and nebulae. A prism is used instead of a diagonal flat.

As can be seen in the picture, the telescope is mounted on four iron wheels. It runs on a steel track in and out of a special room back of the garage which was built by me. Also seen in the picture is my 6-inch reflector. These telescopes were completely built in the shop of A. H. Hearne, in Oklahoma City, and I assisted in the grinding of the larger mirror.

RUSSELL W. WILKERSON
3329 N.W. 25th
Oklahoma City, Okla.

**GLEANINGS is always ready to receive reports and pictures of amateur instruments and devices, and is open for comment, contributions, and questions from its readers.**

# OBSERVER'S PAGE

**Universal time is used unless otherwise noted.**

## Saturn's Rings and Transits of Titan in 1950

THE YEAR 1950 is one of those infrequent ones when the rings of Saturn disappear from view as their plane passes through the earth. This will occur in September, when the planet is hidden by the rays of the sun less than two days before conjunction. It should be of great interest to observe the changes in the aspects of the rings and in the transits, occultations, and eclipses of the brightest satellite, Titan, which revolves in the plane of the rings but at a greater distance from the planet. All these are greatly influenced by the position of the earth in its orbit just as is the familiar apparent retrograde motion near opposition.

Fig. 1 shows a graph of the inclination of the plane of the rings to the line of

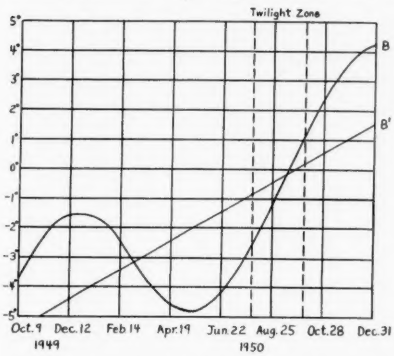



**Fig. 1. The inclination of Saturn's rings.**

sight. It is plotted from data tabulated for eight-day intervals in the **American Ephemeris and Nautical Almanac.** Curve B is for the terrestrial observer and shows the latitude of the earth measured with respect to the ring plane, while B′ is similarly plotted for an imaginary observer at the sun. Values are positive when the northern side of the rings is in view. The dashed lines define the dates within which Saturn will be above the horizon only during twilight at latitude 40° north.

Note that the inclination of the rings reached a minimum of 1°.46 during December, near the time that the planet was stationary in right ascension. With respect to the sun, the intersection of the ring plane with that of the earth's orbit is moving at virtually the same rate as the planet does in its orbit. The rate changes only slightly over the period of a year so that the graph of B′ is approximately a straight line. The earth is, of course, moving much faster so that near opposition, when the two planets are traveling in nearly the same direction, the earth gets farther away from the ring plane, as shown in Fig. 2. Then in May the inclination of the rings will reach a maximum of 4°.82, whereupon the rings will resume closing until they appear edgewise from first the earth and then the sun in September.

It will be interesting to compare the appearance of Saturn in May to that last December. Although to our view the rings will be open in May more than three times as much, they will be getting only half as much light from the sun as during the earlier month. When Saturn was observed on November 15, 1949, with a 130-power refractor of six inches aperture, the front and rear components of the rings could not be resolved. Will it be possible to distinguish them in May, when the planet will cross the meridian during convenient evening hours? By the time the rings close again to the small angle at which they were open in December, it will be impossible to detect Saturn in the twilight. This will take place about August 20th.

For observers with instruments of moderate aperture, Titan holds by far the most interest of all Saturn's moons. The diagram reproduced from the **American Ephemeris** in the January issue shows that at the time of opposition on March 7th the orbit of Titan just clears the ball of the planet. On the other hand, the drawing that appeared in the December issue by courtesy of the British Astronomical Association showed it to pass in front of and behind the disk. Again this is a consequence of the motion of the earth causing the apparent orbit of the satellite to open up from December to May just as does that of the rings. Accordingly, during the late fall and early winter, Titan has been undergoing transit and occultation at each revolution. At the same time the shadow of the moon passed north of the disk at inferior conjunction, while the moon passed south of Saturn's umbra at superior conjunction. Early in March, the shadow and satellite narrowly miss the disk by equal amounts, but during the spring there will be eclipses and shadow transits without occultations and physical transits. The characteristics of successive eclipses and shadow transits change linearly just as does the Saturnicentric latitude of the sun in curve B′ of Fig. 1, because they are solely a function of the inclination of

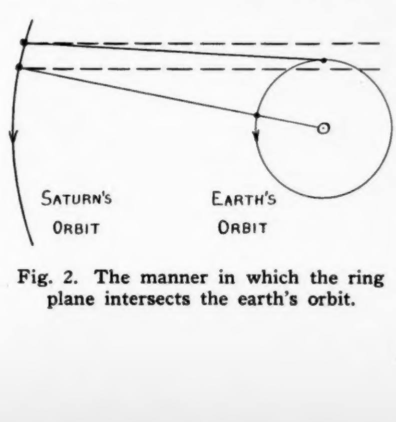



**Fig. 2. The manner in which the ring plane intersects the earth's orbit.**

### UNIVERSAL TIME (UT)

**TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.**

the plane of Titan's orbit to the line joining planet and sun.

Circumstances in 1950, combined with the 16-day period of Titan's revolution, render it fortuitous for observers in the United States to witness these phenomena. The writer saw the transit on December 14, 1949, during early dawn when Saturn was near the meridian. It seemed as though the satellite were visible as a faint dark spot about 60 per cent of the way out from the center of the planetary disk toward the northern limb.

The following table from the **American Ephemeris** lists the times of conjunction that are observable in this country after February 1st. The actual transits may occupy several hours, so the reader should bear in mind that the times given are for the middle of the phenomena, which should bear watching for as much as three hours earlier or later. With the table are the author's estimates of characteristics of certain conjunctions. It is, of course, conceivable that some of the transits, eclipses, and occultations may be partial.

CONJUNCTIONS OF TITAN

**Superior Conjunction**

| Date | | Hour | |
|---|---|---|---|
| February | 8 | 10.7 | |
| | 24 | 8.3 | (2) |
| March | 12 | 5.7 | |
| | 28 | 3.2 | (4) |
| April | 13 | 0.9 | |
| | 28 | 23.0 | |
| May | 14 | 21.5 | |

**Inferior Conjunction**

| Date | | Hour | |
|---|---|---|---|
| February | 16 | 4.9 | (1) |
| March | 4 | 2.5 | |
| | 20 | 0.0 | (3) |
| April | 4 | 21.7 | |

(1) Last transit of the satellite.
(2) Last occultation.
(3) First shadow transit.
(4) First eclipse.

There will be eclipses and shadow transits at later dates, but they will all take place during daylight hours in this country.

In September, the dates when the plane of Saturn's rings passes through first the earth and then the sun fall within a week of each other. As a result the aspects in 1951 will be somewhat similar to those in 1950, but occurring in reverse order with the north side of the rings in view.

PAUL W. STEVENS
Rochester Academy of Science

## VARIABLE STAR MAXIMA

February 5, R Aquilae, 6.3, 190108; 7, R Geminorum, 7.1, 070122a; 16, R Centauri, 5.9, 1409**59**; 19, U Orionis, 6.6, 054920a; 20, S Sculptoris, 6.8, 0010**32**; 25, R Horologii, 6.0, 0250**50**; 25, T Columbae, 7.6, 0515**33**; 26, R Bootis, 7.3, 143227.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

## MINIMA OF ALGOL

February 2, 9:01; 5, 5:50; 8, 2:40; 10, 23:29; 13, 20:18; 16, 17:08; 19, 13:57; 22, 10:46; 25, 7:36; 28, 4:25. March 3, 1:14; 5, 22:04; 8, 18:53.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope**, Vol. VII, page 260, August, 1948, for further explanation.

## DRAWING LUNAR FEATURES

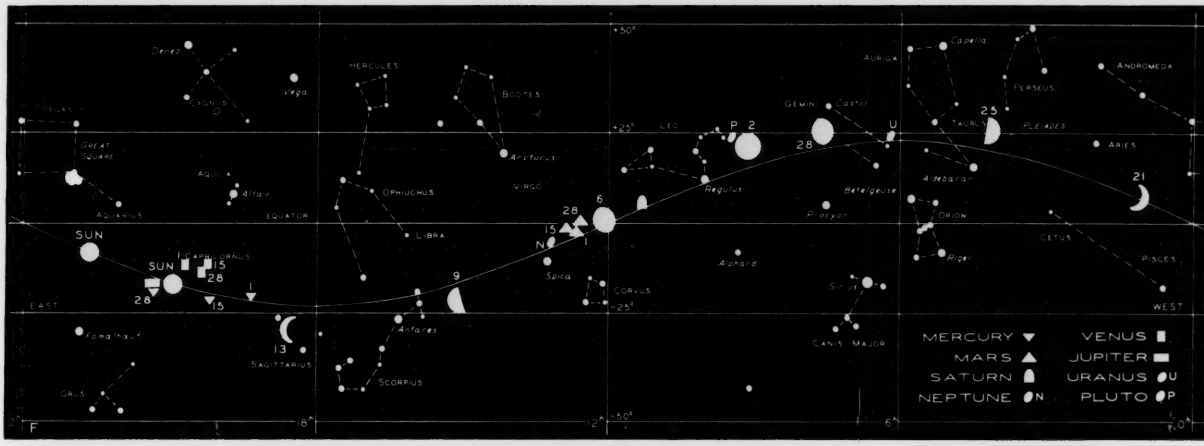
WE THINK THAT a lot of enjoyment is lost by amateurs everywhere because they do not draw what they see. There is no question but that photography has taken astronomy out of its swaddling clothes. There is no argument there.

Still, it is gratifying and just plain fun to sit at the ocular and sketch that which meets the eye. Who cares that we are not artists, that our medium perhaps is no more than the lowly lead pencil? Put down boldly the mountains of the moon, the craters, valleys — and note how, for the first time, small detail is really seen. Indeed, this might be called a lesson in seeing.

**Sunrise on Plato and the Alpine Valley, drawn by J. W. Graham, July 3, 1949; moon's age 7 2/3 days; 80x with a 10-inch reflector.**

Come then while the moon is clearing the mists on the horizon, clearing the garden wall, and uncap. Sit with pad and a small light (this last to be turned on and off alternately) and rough in a sketch. Old fashioned? Perhaps . . . . But like the boyhood fishing hole and its attendant memories, it's mighty good, believe me.

JULIAN WALLACE GRAHAM
P.O. Box 764, Salem, Ore.




## THE SUN, MOON, AND PLANETS THIS MONTH

**The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.**

**Mercury** will be found in the morning sky well placed for viewing most of the month. The most favorable time will be near greatest elongation February 10th, the planet being 25° 53′ west of the sun. On that date Mercury, of zero magnitude, rises over an hour before the sun.

**Venus** rapidly emerges as a morning star, from inferior conjunction with the sun on January 31st. Due to the position of Venus, 7½° north of the ecliptic, the planet rises three quarters of an hour before the sun on February 1st, and may favorably be observed in a telescope. The disk will be one per cent illuminated and 1′ in diameter, hence extremely thin. By mid-February, Venus rises 1½ hours before sunrise and will be eight per cent illuminated. Its magnitude will have increased to −4.0.

**Mars** will be noticed as the bright ruddy object rising 4½ to two hours after sunset. The magnitude of Mars increases from +0.1 to −0.6 during the month. Mars begins retrograde motion on the 13th; this may be followed by watching its relation to the nearby 3rd-magnitude star, Gamma Virginis, through February.

The Martian disk will be large enough for telescopic observation, 13″ diameter at the end of February. The seasons on Mars are now winter in the southern hemisphere and summer in the northern.

**Jupiter** passes conjunction with the sun on February 3rd, entering the morning sky.

**Saturn,** well placed for observation, rises in eastern Leo after sunset. The ringed planet is in retrograde motion and shines as a star of 1st magnitude. A close conjunction with the moon will take place on February 5th, at 9:47 UT, the planet geocentrically 25′ north of the moon's center.

**Uranus** will be above the horizon until early morning, located 2° northwest of Eta Geminorum, and south of the open cluster M35. This distant planet remains in retrograde motion and is of the 6th magnitude.

**Neptune** rises before midnight and is about midway from Mars to Spica, very near Theta Virginis, as the chart on the next page shows. Neptune is also in retrograde motion, and of the 8th magnitude.

E. O.

## OCCULTATION PREDICTIONS

February 4-5 **Sigma Leonis** 4.1, 11:18.6 +6-18.2, 18, Im: **F** 8:23.0 ... ... 67; **H** 7:31.8 −1.6 +0.7 99. Em: **F** 8:55.6 ... ... 18; **H** 8:35.5 −0.9 −1.9 337.

February 9-10 **A Scorpii** 4.8, 15:50.6 −25-10.8, 23, Im: **A** 11:46.2 −1.9 −0.3 98; **C** 11:38.5 −2.0 −0.3 107; **E** 11:15.5 −1.4 −0.2 125; **F** 11:15.6 −0.4 −1.6 160. Em: **A** 13:04.9 −1.7 −1.2 300; **C** 13:00.8 −1.9 −1.0 295; **E** 12:33.4 −1.9 −0.3 285; **F** 12:15.3 −2.8 +0.8 257.

**For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.**

**The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.**

**Longitudes and latitudes of standard stations are:**

| | | | | | |
|---|---|---|---|---|---|
| A | +72°.5, | +42°.5 | E | +91°.0, | +40°.0 |
| B | +73°.6, | +45°.6 | F | +98°.0, | +30°.0 |
| C | +77°.1, | +38°.9 | G | +114°.0, | +50°.9 |
| D | +79°.4, | +43°.7 | H | +120°.0, | +36°.0 |
| I | +123°.1, | +49°.5 | | | |

## MOON PHASES AND DISTANCE

| | | |
|---|---|---|
| Full moon | February | 2, 22:16 |
| Last quarter | February | 9, 18:32 |
| New moon | February | 16, 22:53 |
| First quarter | February | 25, 1:52 |
| Full moon | March | 4, 10:34 |

| | February | Distance | Diameter |
|---|---|---|---|
| Perigee | 7d 0h | 228,900 miles | 32′ 27″ |
| Apogee | 22d 18h | 251,500 miles | 29′ 31″ |
| | **March** | | |
| Perigee | 6d 13h | 225,500 miles | 32′ 56″ |

The nebula in the sword of Orion, photographed by Claude W. Carpenter. The main portion is designated M42, the lower appendage M43.

## DEEP-SKY WONDERS

AT THIS SEASON, when most of the United States is covered by the cold and transparent blanket of the polar continental air mass, the nebula observer can do no better than direct his telescope to the greatest of all spectacles — the Orion nebula, middle "star" in the mighty hunter's sword. Against the intense, sharp blackness of these skies, with the stars actually resembling their prototype diamonds, there is no other sight so well calculated to stir the observer's feelings of awe and wonder.

The nebula stands up well under all sizes of telescope and all powers. With high magnifications, the intricate curdlings of its luminous masses rival and resemble frost paintings. With low powers and a field wide enough to include the whole nebula, it becomes an object compelling enough to draw exclamations of delight from even the most disinterested bystander. The observer should use averted vision until he can trace the luminous beauty of the Orion nebula far beyond the bounds normally assigned to this entrancing object.

WALTER SCOTT HOUSTON

## A LINEUP OF PLANETS

Brilliant Venus high in the evening sky, with Jupiter below it and Mercury in line still nearer the horizon, gave amateur observers an unusual sight during the latter part of December and in early January. Paul W. Stevens, who described in the January issue his monthly observations of Mercury during 1949, completed the year's feat on the evenings of December 29 and 30, at which times he also enjoyed excellent views of Venus and Jupiter.



## PREDICTIONS OF BRIGHT ASTEROID POSITIONS

CINCINNATI OBSERVATORY's Minor Planet Center has prepared a special list of predicted places for 24 bright asteroids that come to opposition in 1950. The ephemerides for four of these are given below, and the others will be published here at appropriate times during the year. The published list contains in addition such information as the mean anomaly, the logarithm of the heliocentric distance, and the logarithm of the geocentric distance, all for the date of opposition. Anyone wishing this list (on two mimeographed sheets) may obtain it by sending a self-addressed stamped envelope to the Cincinnati Observatory, Cincinnati 8, Ohio.

The Minor Planet Center also publishes annually a complete volume of opposition ephemerides for all suitable asteroid orbits.

| No. 3 | | Juno | | Mag. 9.1 | |
|---|---|---|---|---|---|
| | | h | m | ° | ′ |
| Feb. | 18 | 12 | 8.3 | −00 | 44 |
| | 28 | 12 | 2.3 | +00 | 39 |
| Mar. | 10 | 11 | 54.8 | + 2 | 12 |
| | 20 | 11 | 46.8 | + 3 | 48 |
| | 30 | 11 | 39.2 | + 5 | 16 |
| Apr. | 9 | 11 | 32.7 | + 6 | 32 |

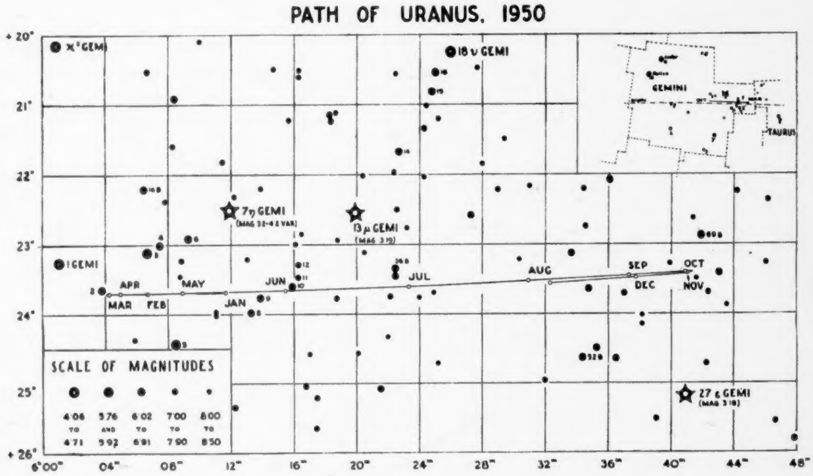
| No. 5 | | Astraea | | Mag. 9.0 | |
|---|---|---|---|---|---|
| | | h | m | ° | ′ |
| Feb. | 28 | 12 | 16.7 | + 3 | 23 |
| Mar. | 10 | 12 | 10.3 | + 4 | 44 |
| | 20 | 12 | 2.5 | + 6 | 07 |
| | 30 | 11 | 54.7 | + 7 | 21 |
| Apr. | 9 | 11 | 48.3 | + 8 | 17 |
| | 19 | 11 | 43.9 | + 8 | 47 |

| No. 532 | | Herculina | | Mag. 8.7 | |
|---|---|---|---|---|---|
| | | h | m | ° | ′ |
| Feb. | 28 | 12 | 36.2 | +22 | 54 |
| Mar. | 10 | 12 | 31.1 | +24 | 49 |
| | 20 | 12 | 24.0 | +26 | 23 |
| | 30 | 12 | 16.3 | +27 | 25 |
| Apr. | 9 | 12 | 9.1 | +27 | 49 |
| | 19 | 12 | 3.6 | +27 | 34 |

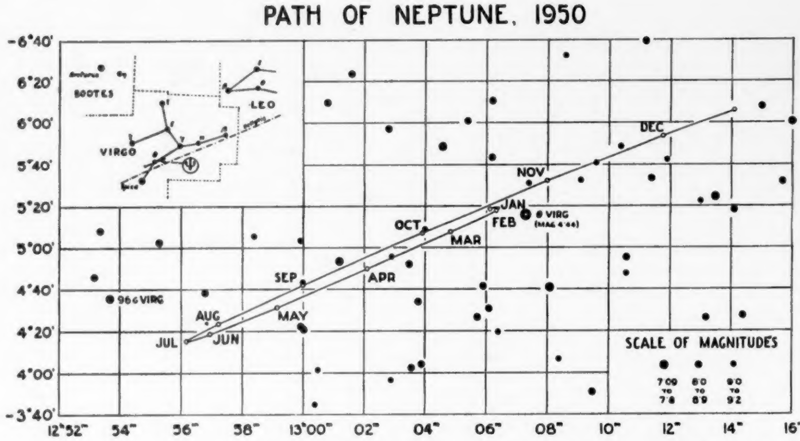
| No. 516 | | Amherstia | | Mag. 9.3 | |
|---|---|---|---|---|---|
| | | h | m | ° | ′ |
| Mar. | 10 | 12 | 51.6 | −20 | 21 |
| | 20 | 12 | 43.9 | −21 | 42 |
| | 30 | 12 | 34.1 | −22 | 37 |
| Apr. | 9 | 12 | 23.5 | −23 | 05 |
| | 19 | 12 | 13.6 | −23 | 08 |
| | 29 | 12 | 6.1 | −22 | 50 |

The above are predicted positions in right ascension and declination for the epoch 1950.0, for $0^h$ Universal time. The magnitude is that expected at opposition. In each case the motion of the asteroid is retrograde.

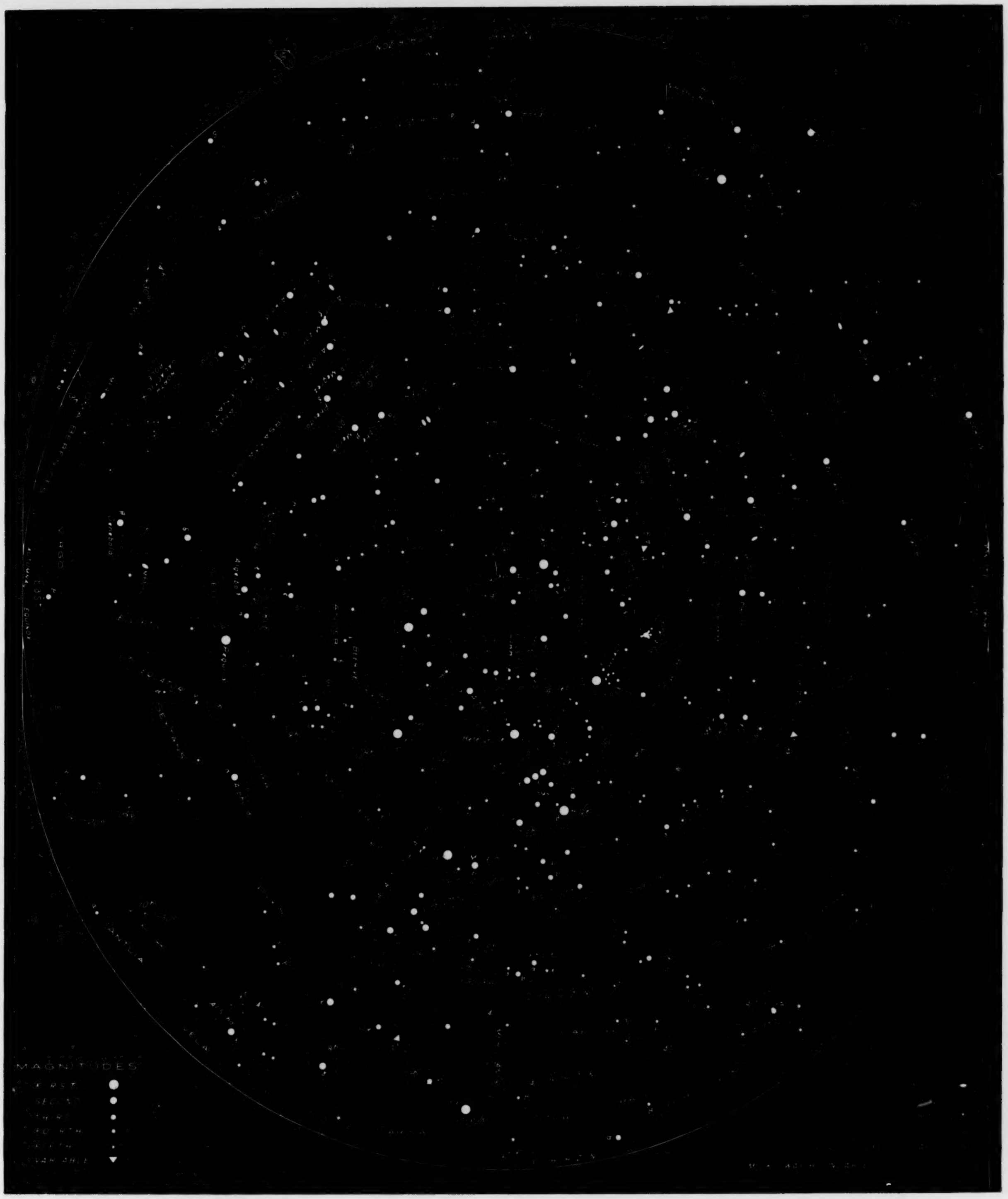
### PATH OF URANUS, 1950




### PATH OF NEPTUNE, 1950




The paths of Uranus and Neptune among the stars during 1950, from the "Handbook" of the British Astronomical Association. The fields are inverted, with south at the top, as seen in an astronomical telescope.



**The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of February, respectively.**

## STARS FOR FEBRUARY

CONTINUING our discussion of chart characteristics and uses begun last month, we consider the point overhead.

**Point overhead.** This is not labeled on charts because it is different for each observer with a different latitude, a basic principle of navigation. Your own point overhead can be found by counting upward along the meridian from the intersection of the equator and the meridian a number of degrees equal to your latitude. At the chart time the zenith point is in the center of the above chart for an observer at latitude 40° north; at the center of our southern charts for an observer at latitude 30° south.

**Stereographic projection.** These charts are based on the stereographic projection, in which the observer is considered to be at the extremity of one diameter of the sphere (at the nadir) instead of at its center, where he is in reality. All points on the hemisphere opposite him are projected on a plane perpendicular to and situated at the other extremity of the same diameter (at the zenith). This kind of projection results in no distortion in azimuth, and the distortion in altitude is such as to crowd the constellations together at the chart center, corresponding closely with the illusion of the real sky.